**OAK RIDGE
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**Transportation and Packaging Issues
Involving the Disposition of Surplus
Plutonium as MOX Fuel
in Commercial LWRs**

**S. B. Ludwig
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Fissile Materials Disposition Program

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S. B. Ludwig, R. E. Best, S. P. Schmid, and D. E. Welch

ABSTRACT

This report provides a view of anticipated transportation, packaging, and facility handling operations that are expected to occur at mixed-oxide (MOX) fuel fabrication and commercial reactor facilities. This information is intended for use by prospective contractors to the U.S. Department of Energy (DOE) who plan to submit proposals to DOE to manufacture and irradiate MOX fuel assemblies in domestic commercial light-water reactors. The report provides data to prospective consortia regarding packaging and pickup of MOX nuclear fuel assemblies at a MOX fuel manufacturing plant and transport and delivery of the MOX assemblies to nuclear power plants. The report also identifies areas where data are incomplete either because of the status of development or lack of sufficient information and specificity regarding the nuclear power plant(s) where deliveries will take place.

1. INTRODUCTION

On January 14, 1997, the Department of Energy (DOE) issued its Record of Decision (ROD) on the storage and disposition of surplus nuclear weapons materials.¹ The ROD committed DOE to undertake a dual-track program to disposition surplus plutonium by (1) immobilization in ceramic or glass forms for long-term storage and (2) fabrication of mixed-oxide (MOX) reactor fuel for use in existing commercial nuclear power plants. The result of these efforts would make the plutonium *as inaccessible as the growing inventory of plutonium in commercial LWR spent fuel* for proliferation purposes.

The ROD represents a milestone in the process prescribed under the National Environmental Policy Act of 1969 (NEPA). Supporting the ROD are a number of key documents, including (1) the DOE's final programmatic environment impact statement,² (2) the Office of Fissile Materials Disposition's technical summary report,³ (3) Oak Ridge National Laboratory's (ORNL's) reactor alternative summary reports,⁴⁻⁷ (4) the Proliferation Vulnerability Red Team's assessment report,⁸ and (5) the Office of Arms Control and Nonproliferation's assessment of plutonium disposition.⁹ Together, these documents provide a comprehensive assessment of the environmental, cost, schedule, technical, and nonproliferation risks associated with the proposed disposition of surplus plutonium. During the coming months, DOE will be (1) enlisting the participation of private industry to provide MOX fuel fabrication and reactor irradiation services, and (2) preparing site-specific environmental impact statements that will permit DOE to finally select particular sites for the construction of facilities needed to implement the disposition of surplus plutonium. A series of packaging and transportation steps will link selected facility sites. This report focuses on the transportation of fresh MOX fuel.

Transportation and packaging of unirradiated MOX fuel from the MOX fuel fabrication facility to commercial nuclear reactor(s) involved in the disposition mission will utilize DOE's safe-secure trailers (SSTs) and packages designed and certified to accommodate fresh (unirradiated) MOX fuel assemblies. Based on the Nuclear Regulatory Commission (NRC) regulations [Title 10 *Code of Federal Regulations* (CFR) Part 71], a Type B package is required when transporting commercial quantities of plutonium materials. The packaging must satisfy regulations with respect to containment, criticality, shielding, and heat dissipation. To satisfy the regulations, the package must be able to withstand a series of regulatory tests including (1) a 9-m drop onto an unyielding surface, (2) a 1-m drop onto an unyielding punch, (3) a fully engulfing fire at 800°C for 30 min, and (4) immersion in 15 m of water for 8 h. Following these tests, the

package must also satisfy the containment criteria set out in the regulations. The SSTs are utilized to provide security for the MOX fuel in transit (i.e., to meet the physical protection requirements for Category I quantities of special nuclear material). Due to the need for a new MOX fuel package and the time required to develop and certify a new design, ORNL was tasked with developing a conceptual design for a MOX fresh fuel package to best utilize the payload limitations of the SST. The Type B package provides the required safety during transport, while the SST provides physical protection for the cargo.

2. PURPOSE AND BACKGROUND

2.1 PURPOSE

This report presents information concerned with the transport of unirradiated MOX nuclear power reactor fuel assemblies from the MOX fuel fabrication facility to several specifically selected domestic commercial light-water reactors. This information is intended for use by prospective contractors to DOE who plan to submit proposals to DOE to manufacture and irradiate MOX fuel assemblies in domestic commercial light-water reactors. The principal fissile constituent in these MOX assemblies is derived from disposition of surplus plutonium. The report provides data to prospective consortia regarding packaging and pickup of MOX nuclear fuel assemblies at a MOX fuel manufacturing plant and transport and delivery of the MOX assemblies to nuclear power plants. The report also identifies areas where data are incomplete either because of the status of development or lack of sufficient information and specificity regarding the nuclear power plant(s) where deliveries will take place. Relative to information contained in this report, prospective offerors are invited to provide DOE with additional information and suggestions that can be used to improve understanding of the interface between DOE's MOX transportation system and nuclear power plant receiving facilities and operations.

2.2 BACKGROUND

As described in the *Program Acquisition Strategy for Obtaining Mixed-Oxide Fuel Fabrication and Reactor Irradiation Services*,¹⁰ DOE plans to enter into contracts with private sector consortia who will design and manufacture MOX fuel assemblies containing fissile plutonium recovered from U.S. nuclear weapons program activities and who will provide nuclear power reactor irradiation services for the MOX fuel. The DOE's objective is safe, permanent, and secure disposition of the plutonium.

Because of the need to provide a high level of physical security in transportation of MOX fuel assemblies, DOE will be the exclusive, specialized carrier that will transport MOX nuclear fuel by truck from a consortia-operated MOX fabrication facility located at a DOE-managed site to the commercial nuclear power plant(s). Because developing and certifying a new package design requires typically 5 to 7 years, DOE has tasked ORNL with developing concepts for a new MOX fuel package. Early development efforts give DOE a 2-year head start on package development as insurance against later delays. Preliminary design goals for the new MOX fuel package are that (1) the package is compatible with and efficiently uses available payload capacity of the SST, and (2) the package will be certified by the NRC in accordance with requirements prescribed in 10 CFR 71. Additionally, as described in this report, the package must be compatible with MOX fuel fabrication and nuclear reactor fuel-handling capabilities, even though some plant modifications may yet be necessary. While DOE will maintain the certificate for the package, the consortia will be responsible for (1) becoming registered users of DOE's MOX fresh fuel package and (2) purchasing and maintaining sufficient packagings to meet the anticipated delivery schedule. Although an estimate of the cost to purchase each package has not been developed yet, prospective bidders should use an estimate of \$100,000 per package for bidding purposes.

DOE anticipates that it will enter into an operating agreement for the transportation services with the consortia; this agreement will specify the understandings between DOE and the consortia regarding exchanges of shipment information, operating responsibilities, shipment scheduling, and other topics necessary for effective coordination of shipping activities. Except for MOX package ownership costs, DOE currently anticipates that DOE funds will be used to pay the full cost of the MOX fuel transportation

services that it provides. Except for returns of defective, unirradiated MOX fuel assemblies to the consortia-operated MOX fuel fabrication plant (discussed in Sect. 3.6), DOE does not anticipate any transfers of unirradiated MOX fuel assemblies from the commercial reactor plant to other sites. Should such transfers take place, the consortia will coordinate with DOE to arrange for necessary transportation services.

DOE recognizes that present-day operations at nuclear power plants which involve receiving and handling low-enriched uranium (LEU) fuels are likely to change from those that will be necessary for the consortia's MOX fuels. Nonetheless, it is expected that the commercial nuclear power plant owner will take possession of the MOX fuel assemblies upon receipt and will handle them according to applicable law, state and local statutes and regulations, and federal regulations (including NRC regulations), and in conformance with plant technical specifications and procedures. The consortia will be responsible for preparation of and obtaining approvals of any and all safety analyses, permits, technical specifications, and procedures that are necessary to address safety, strategic special nuclear material safeguards and security, and other regulatory or statutory requirements associated with MOX fuel assembly receiving and handling at the commercial nuclear power plant. DOE intends to enter into an operating agreement with the consortia, that will establish assignments of responsibilities; organizational relationships; operating policies, protocols, and procedures; and information exchanges that will be necessary to coordinate SST physical security and delivery operations and plant safeguards and security and receiving operations.

3. CONCEPT OF OPERATIONS

The following discussion presents information regarding DOE's concept of operations for use of its MOX transportation system to pick up, transport, and deliver unirradiated MOX nuclear reactor fuel to commercial nuclear power plants. This concept of operations characterizes interfaces between DOE's MOX fuel transportation system and the MOX fuel fabrication plant and the mission nuclear power plant(s). It includes (1) DOE's SST vehicles, (2) associated transportation physical security operations, (3) the MOX transportation package, and (4) the consortia's nuclear fuel-handling operations and associated storage facilities. Finally, the descriptions and information provided are based on present-day law and policies of the U.S. Government, including DOE policies and orders, and federal, state, and local regulations.

The DOE's concept of operations for MOX transportation addresses the following:

- Pick-up operations at a MOX nuclear fuel fabrication plant
- In-transit operations in SSTs of unirradiated MOX nuclear fuel
- Delivery of MOX fuel at nuclear power plants
- MOX package handling and unloading
- Return of MOX packages to a MOX fabrication facility
- Return of defective MOX fuel assemblies to a MOX fabrication facility

3.1 PICKUP OPERATIONS AT A MOX PLANT

The DOE SST operations team will direct and approve loading and securement of packages within SST vehicles and will be solely responsible for closing and securing SST vehicles cargo areas prior to transport. DOE will take custody of packaged MOX nuclear reactor fuel loaded on SST vehicles for transport at a MOX fuel fabrication plant. DOE will require that the MOX plant operator fully comply with the NRC certificate of compliance for the package and applicable NRC and U.S. Department of Transportation (DOT) regulations in preparing and offering packaged MOX fuel for transportation, including proper shipping papers and nuclear material transfer forms. DOE anticipates that, if applicable, approved International Atomic Energy Agency (IAEA) safeguard seals will be placed on packages in accordance with established protocols and procedures by the MOX plant operator, DOE, and other cognizant authorities prior to release of loaded packages for transport. IAEA safeguard seals may also be applied to transport vehicles. The consortia's MOX plant operator will not be responsible for IAEA safeguards provisions that affect SST vehicles, equipment, or operations. Figure 1 provides an example of one of DOE's SST tractors. Table 1 provides general information about the dimensions of the SST.

Fig. 1. DOE SST vehicle.

Table 1. General dimensions for a DOE SST

Gross vehicle weight (GVW) rating	80,000 lb
Maximum payload	13,600 lb
Tractor trailer overall length	60 ft
Tractor trailer overall width	102 in.
Tractor trailer overall height	13 ft
Trailer rear door width	70.5 to 85 in.
Trailer rear door height	90 in.
Trailer floor height above roadway, empty	56.5 in.
Trailer floor height above roadway, fully loaded	56.5 in.
Tractor trailer minimum turning radius	37.5 ft

Task interactions between SST operations teams, the SST operations center, and the consortia's MOX plant operations and security personnel involved in loading, securing, and dispatching SST shipments will be conducted in accordance with the requirements of DOE Orders 5610.14, 5632.2A, and 5633.3B and SST operations procedures. The consortia's MOX plant operator will provide necessary labor, loading areas and docks, and package-handling equipment that is necessary for loading MOX transportation packages into SSTs. In addition, MOX plant personnel will perform all necessary pre-shipment health physics surveys necessary prior to release of SST shipments for dispatch. MOX plant personnel involved in fuel-handling operations will be required to have a "need to know" and possess either appropriate NRC [per 73.50(c)(1)] or DOE Level 3 (per DOE M 5632.1C-1, II, 2) access authorizations. In dispatching shipments of MOX fuel to the commercial nuclear power plant, DOE's SST operations team and operations center will also coordinate with the security operations center at the DOE site where the MOX facility is located. Estimated time of arrival, shipment, and material accountability information will be transmitted to designated persons at the commercial nuclear power plant in accordance with prearranged protocols. DOE anticipates the time necessary to prepare, load, secure, and dispatch SSTs to be on the order of less than 1 d (per convoy).

3.2 IN-TRANSIT OPERATIONS

Upon taking custody and following release by the SST dispatcher, a DOE SST operations team will provide safe, secure, and through transport for MOX nuclear fuel from the MOX fuel fabrication plant to a specified commercial nuclear power plant. Transportation activities will comply with applicable DOE orders governing transport of strategic special nuclear materials (SSNM), the terms of the operating agreement between DOE and the consortia, and associated policies and procedures. In addition, off-site packaging and transportation of MOX nuclear fuel will comply with DOT regulations governing safe transportation of Type B quantities of fissile radioactive materials with these exceptions:

- For in-transit security reasons, SST operations will not be subject to roadside safety inspections conducted by federal, state, or tribal authorities, but will be subject to strict DOE operations safety requirements that meet or exceed Federal Motor Carrier Regulations.
- SSTs being monitored through the use of satellite tracking, or its equivalent, and accompanied by security escorts during transportation will not display radioactive material placards.
- To comply with DOE order requirements governing in-transit physical security for formula-quantities of SNM, preshipment notifications to state and tribal governments will not be made.
- Routes used for transportation of MOX fuel will be selected with emphasis on requirements for in-transit safety and physical security and therefore may not, in all circumstances, comply with DOT requirements for shipments of highway-route-controlled quantities of radioactive materials.

Off-site transportation of each SST carrying fresh MOX fuel will be coordinated by the DOE transportation Safeguards Division, using well-established systems and procedures. On-site transportation activities at the DOE site will comply with applicable DOE orders (e.g., DOE Order 460.1A—*Packaging and Transportation Safety*).

3.3 DELIVERY OPERATIONS AT A NUCLEAR REACTOR PLANT

The SST shipments of unirradiated MOX fuel assemblies arriving at a nuclear power plant for delivery will be received in accordance with procedures and protocols established in an operating agreement between DOE's SST operations and the consortia's nuclear power plant operator. Because of the security inherent in SST operations, DOE anticipates that usual plant procedures requiring vehicles coming onto a plant's site to be inspected for explosives and contraband by plant security forces will not apply to SST deliveries of MOX fuel. DOE anticipates that SSTs will arrive and be met, verified, and escorted by the plant's security force through security barriers to a designated MOX receiving area at the reactor plant [expected to be the plant's auxiliary building for pressurized-water reactor (PWR) plants and at the reactor building for boiling-water reactor (BWR) plants]. As with deliveries of unirradiated LEU reactor fuel by commercial carriers, upon arrival at the receiving area, delivery vehicles (SSTs in this case) will be backed into the facility. However, unlike commercial vehicles, tractor and trailer units should not be separated and must be operated only by DOE drivers. Thus, plant receiving areas should be capable of accommodating and have sufficient clearance for unloading a full-length SST vehicle. DOE anticipates that the SST will be unloaded in an enclosed facility that meets the physical protection requirements for an NRC Category I facility. Specific details for meeting required facility security measures when unloading the SST will need to be developed on a case-by-case basis.

On the basis of data presented in Tables 2 and 3, which have been compiled by ORNL, and typical facility layouts for BWRs (as illustrated in Figs. 2 and 3) and PWRs (as illustrated in Figs. 4 and 5), most commercial nuclear power plants would be able to receive and unload SSTs. Modifications to receiving area buildings may be required, depending on interpretations of physical security requirements, such as erection of temporary barriers and allowances for a suitable guard force in lieu of an enclosed space to contain the entire SST during loading and unloading operations. Alternatively, the nuclear power plant owner may elect to provide a separate, secure on-site storage facility for unloading and lag storage of MOX fuel assemblies.

When shipments involve convoys of two or more (typically three SSTs operate in a convoy) SST vehicles, reactor plant operators may be requested to provide secure areas for parking of loaded SST

Table 2. Dimensions of representative BWR plant receiving areas^a

1. Receiving area overall length	76 ft-6 in. to 126 ft (including outer airlock)
2. Receiving area width (normally the width of the outer door)	14 ft-6 in. to 21 ft-6 in. (minimum)
3. Receiving area ceiling height	21 ft to 49 ft-6 in. (minimum)
4. Hatchway opening (through which the package must pass)	14 ft-7 in. to 31 ft-8 in. (minimum)
5. Elevation above receiving area floor to refueling area	18 ft to 165 ft-11 in.

^aThese data were taken from a representative sampling of BWR reactor buildings.

Table 3. Dimensions of representative PWR plant receiving areas^a

1. Receiving area overall length	71 ft to 187 ft-6 in.
2. Receiving area width (normally the width of the outer door)	15 ft-9 in. to 22 ft (minimum)
3. Receiving area ceiling height	18 ft to 26 ft (minimum)
4. Hatchway opening (through which the package must pass)	11 ft-1 in. to 15 ft-8 in. (minimum)
5. Elevation above receiving area floor to refueling area	0 ft to 28 ft

^aThese data were taken from a representative sampling of PWR auxiliary buildings.

vehicles. During vehicle positioning operations, DOE anticipates that the reactor plant's security force will provide physical security for receiving operations in accordance with the applicable requirements of 10 CFR 73, the plant's NRC license, applicable technical specifications, and plant-specific policies and procedures. Protocols established by the operating agreement between DOE's SST operations and the reactor plant's operator will spell out safeguards and security procedures and respective responsibilities for SST operators and escorts, plant operations personnel, and plant security force personnel.

After an SST is positioned in a plant's receiving bay area, security seals on its cargo area will be removed, the cargo area will be opened, and any coverings and attachments that secure the MOX packages in the SST cargo area will be removed. Before removing the MOX package from the SST, DOE anticipates that a receiving radiation/contamination survey will be conducted. DOE will require that the SST operators, who will hold DOE Level 3 clearances and the requisite need to know, observe these and other receiving activities and maintain surveillance of the SST and MOX package payload until the package is removed from the SST, material accountability documentation has been transferred and verified, and plant operations formally takes possession of the shipment. At this time, DOE will require that the SST operators obtain necessary release documents and direct closure and sealing of the SST cargo area. SST operators will continue to maintain visual surveillance and physical control of the SST at all times. Figures 6 and 7 illustrate examples of two different types of proposed "end-loading" and "lateral-loading" MOX packages being removed from an SST and fuel being unloaded. As illustrated in Fig. 6, the end-loading concept would probably be situated with its long axis vertical for loading and unloading of individual fuel assemblies. In contrast, the double-strongback concept, as shown in Fig. 7, would be situated on the fueling floor, and the strongbacks would be elevated to vertical to allow the MOX fuel to be removed laterally and placed into storage. DOE expects the consortia to provide all necessary labor, equipment, procedures, and other support services necessary to remove MOX packages from SSTs at the consortia's reactor plants.

Following delivery of a loaded MOX fuel package to a reactor plant, SSTs will be dispatched by SST operations. Once dispatched, DOE anticipates that the reactor plant security operation will clear SST vehicles and operating crews through security barriers without delay. DOE may request the reactor plant operator to provide a temporary, on-site, secured area for parking SSTs that are awaiting dispatch orders. DOE estimates that the time required to receive, verify, unload, and dispatch an SST will be on the order of 1 d. Return of "empty" MOX packages is discussed in Sect. 3.5.

- ① Truck backs into airlock
- ② Close outer door
- ③ Open inner door
- ④ Roll MOX package onto MOX-Gurney
- ⑤ Move SST back into airlock
- ⑥ Position MOX-Gurney under hatch way opening
- ⑦ Lift MOX package off MOX-Gurney to re-fuel floor
- ⑧ Transfer fuel to fuel vault

AST-797299

Fig. 2. General arrangement sketch of reference BWR reactor building (not to scale).

- 1** Back truck into airlock - maintain ventilation/containment
- 2** Off-load MOX package to MOX transfer cart (gurney)
- 3** Use aux or main hook to move MOX package to refueling floor area
- 4** With package supported, extract fuel assemblies and transfer to new fuel vault (note 4a for "end-loading" package or 4b for "lateral-loading" package)

Fig. 3. Reference BWR fuel building elevation view (not to scale).

AST-797299

Fig. 4. General arrangement sketch of reference PWR plant (not to scale).

AST-797299

Fig. 5. Elevation view of reference PWR plant (not to scale).

- ① Remove MOX package from SST trailer onto MOX gurney.
- ② Stand MOX package upright and move to appropriate handling location.
- ③ Remove outer lid.
- ④ Extract assemblies and place in storage.

AST-7/97299

Fig. 6. MOX fuel package handling—end-loading concept.

- ① Remove MOX package from SST trailer onto MOX gurney
- ② Move to appropriate unloading area.
- ③ Stand MOX assembly strongbacks upright and install support strut.
- ④ Extract 4 assemblies and place in storage.

AST-7/87299

Fig. 7. MOX fuel package handling—lateral-loading concept.

3.4 MOX PACKAGE HANDLING AND UNLOADING

DOE understands that receipt and handling operations at nuclear power plants for unirradiated MOX nuclear fuel assemblies will differ from plant to plant. Although there are differences in operating practices, layout differences between PWR and BWR plants are the most significant. In PWR plants, unirradiated fuel and spent fuel are typically stored in auxiliary buildings that are separate from the reactor's primary containment structures. In BWR plants, unirradiated fuel and spent fuel are typically stored in the "secondary containment" part of the reactor building. Also, for a typical PWR plant, the reactor vessel and associated systems are located at near grade-level; in a typical BWR, the reactor vessel is at a higher than grade-level elevation with both unirradiated and spent nuclear fuel storage located 90 ft or more above grade-level. These dissimilar layouts lead to important differences in how DOE's MOX transportation package will be received, removed from SSTs, handled, and unloaded; they have been considered by ORNL in developing the MOX package conceptual design.

In addition to various plant layouts and operating practices, DOE expects that packaging, transportation, and receiving operations involving MOX fuel assemblies will have important differences from experience with receipt and handling of LEU fuel. One of the primary differences will be in the configuration and operation of the MOX transportation packaging. Unlike Type AF (fissile) packages for unirradiated LEU fuel, the MOX package will be designed and approved as a Type-B(U)F package because of the plutonium content in MOX fuel assemblies.

For unirradiated LEU fuel shipments, typically 6 or 7 of the 6000- to 8500-lb packages containing 12 or 14 PWR assemblies (2 assemblies in a package), or 12 of the 2000-lb packages containing 24 BWR assemblies (2 assemblies in a package) are routinely transported on a commercial tractor-trailer vehicle using open flatbed trailers. A typical Type AF package for PWR fuel assemblies is a 15-ft-long, 3-ft-diam metal cylinder that has clam-shell-like closures; a package for BWR fuel is a 15-ft-long, 2.5-ft-square, wood-encased box with one face of the box being removable to access the fuel assemblies.

In contrast to experience in transporting unirradiated LEU fuel, SSTs are sophisticated, security vehicles with fully enclosed semitrailers. Because of the weight of security countermeasures, for unrestricted interstate legal-weight operations, SST payloads are limited to about 13,500 lb. DOE's MOX package is being designed to make maximum use of the SST payload capacity. On-the-road dimensions of an SST tractor trailer are similar to those for other over-the-road tractor-trailer combinations: ~60 ft long, no more than 8 ft 6 in. wide, and no more than 13 ft 6 in. tall. The vehicle's gross vehicle weight (GVW) does not exceed 80,000 lb.

At present, ORNL has several preliminary concepts for MOX fresh fuel package design under consideration. Preliminary concepts for the package are illustrated in Figs. 8–13. Figure 8 provides an illustration

Fig. 8. End loading—general arrangement.

Fig. 9. Double-strongback package for MOX fuel (PWR version)—general arrangement.

Fig. 10. Double strongback (PWR version)—end view.

Fig. 11. PWR double strongback—cutaway view.

Fig. 12. Double strongback (BWR version)—end view.

Fig. 13. BWR double strongback—cutaway view.

of an end-loading package. Figure 9 provides an illustration of a "double-strongback" concept. The package concepts that are depicted in the figures accommodate either four PWR assemblies or eight BWR assemblies. Figures 10 through 13 depict additional details of the double-strongback concept. All of the package concepts are ~17 to 19 ft long and about 4 ft in cross section or diameter. The target weight for these packages, when loaded, is 13,000 lb.

DOE anticipates that some plant modifications and additional special equipment may be needed for receiving and handling MOX fuel delivered by a SST in the MOX packages:

- A movable platform, as is illustrated in Figs. 6 or 7, or a fixed loading dock to receive MOX packages as they are removed by rolling or sliding them out the back of the cargo area of SSTs. (Note: This will require that the unloading bay area of the plant have sufficient length to accommodate an SST plus the full length of DOE's MOX package when unloading operations are being conducted.)
- Rigging, fixtures, and frames for handling, transferring, and unloading MOX packages in the vertical (standing-up) orientation inside the plant if the Type B(U)F packages have end closures (see package descriptions below).
- Special equipment, procedures, and operating rules to protect MOX fuel assemblies from damage during MOX package handling and unloading.

Plant owners will be expected to be responsible for plant modifications, changes to procedures, and construction of special equipment.

As noted previously, MOX fuel packages will be removed from SSTs by sliding or rolling them out the back of the SST's cargo box horizontally. Following this transfer to a loading dock or movable platform, the package can be lifted and positioned using the same plant overhead cranes used to lift and position LEU fuel packages. DOE can provide the consortia with a general design for the movable SST unloading platform, called the MOX-Gurney, that the consortia's reactor plant owner may procure for use in removing MOX packages from SSTs. Depending on the final design of the MOX fuel package, other special handling equipment or modifications may be needed. DOE will provide designs, sufficient for procurement, for each item of special MOX package-handling equipment that is needed.

3.5 RETURN OF MOX PACKAGES TO A MOX FABRICATION FACILITY

Because plans specify that the consortium will own the MOX packages, the consortia should be responsible for arranging return transportation for empty packages to be reloaded at its MOX fabrication facility. Whenever consistent with efficient use of SSTs, empty MOX packages could be returned to the MOX fuel facility in available SSTs. If not, commercial transportation could be arranged. The consortia should bear full responsibility for the number in service, condition, and use of MOX packages that it may

own. The consortia may be expected to (1) procure packages, spare parts, and consumables and (2) provide inspection and maintenance, quality assurance, recordkeeping, recertification, insurance, and package management.

3.6 RETURN OF DEFECTIVE MOX FUEL ASSEMBLIES TO A MOX FABRICATION FACILITY

Return of defective, unirradiated MOX fuel assemblies to the MOX fabrication plant, if necessary, should involve the reverse of operations required for delivery of MOX fuel assemblies to the consortia's reactor plant. DOE expects that returned full fuel assemblies will be transported in the MOX transportation package using DOE's SST transportation services.

Any irradiated MOX-fuel-bearing assembly components, or MOX fuel assemblies or fuel-bearing assembly components in which the fuel-pellet cladding has been breached would need to be transported in packages having necessary certificate of compliance provisions. If such packages are not suitable for transport in an SST, DOE can be expected to provide alternative transportation arrangements that are mutually determined by DOE and the consortia.

4. SUMMARY AND CONCLUSIONS

Packaging and transportation of fresh MOX fuel assemblies between the MOX fabrication facility and the commercial nuclear reactors is envisioned to require the use of NRC-certified Type B packages and DOE's SST to provide the necessary safety and security for the transportation of the MOX fuel assemblies. ORNL is developing a new package conceptual design to optimize the SST load-carrying capacity. Unloading of new fuel packages from SSTs and handling and removing fuel from these fuel packages for storage within the commercial reactor results in a number of "interface" issues between DOE's transportation system and the package-handling capabilities of commercial nuclear reactors. This report has attempted to, in a generic fashion, describe DOE's MOX packaging and package-handling concepts to provide prospective consortia with as much information as is currently available about the shipment of MOX fuel via the DOE SST.

Currently, ORNL is investigating several preliminary MOX packaging concepts that would meet the requirements of a Type B package under the NRC regulations as well as meet the SST load-carrying limitations. Two leading preliminary concepts that appear to meet the design goals are (1) an "end-loading" package concept and (2) a "lateral-loading" package concept. Based on the assessment of handling capabilities within commercial nuclear power plants, it appears that either concept could be handled at the reactor. DOE recognizes that receiving fresh fuel via SSTs and handling new package designs introduces the potential for modifications to plant equipment, procedures, and safety analyses. DOE encourages prospective consortia to provide additional information and suggestions that can be used to improve the understanding of the interface between DOE's MOX transportation system and the nuclear power plant receiving facilities and operations.

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