Mixed Oxide Fresh Fuel Package Auxiliary Equipment - 8123

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ABSTRACT

The United States Department of Energy's National Nuclear Security Administration (NNSA) is overseeing the construction the Mixed Oxide (MOX) Fuel Fabrication Facility (MFFF) on the Savannah River Site. The new facility, being constructed by NNSA's contractor Shaw AREVA MOX Services, will fabricate fuel assemblies utilizing surplus plutonium as feedstock. The fuel will be used in designated commercial nuclear reactors.

The MOX Fresh Fuel Package (MFFP), which has recently been licensed by the Nuclear Regulatory Commission (NRC) as a type B package (USA/9295/B(U)F-96), will be utilized to transport the fabricated fuel assemblies from the MFFF to the nuclear reactors.

It was necessary to develop auxiliary equipment that would be able to efficiently handle the high precision fuel assemblies. Also, the physical constraints of the MFFF and the nuclear power plants require that the equipment be capable of loading and unloading the fuel assemblies both vertically and horizontally. The ability to reconfigure the load/unload evolution builds in a large degree of flexibility for the MFFP for the handling of many types of both fuel and non fuel payloads.

The design and analysis met various technical specifications including dynamic and static seismic criteria. The fabrication was completed by three major fabrication facilities within the United States. The testing was conducted by Sandia National Laboratories.

The unique design specifications and successful testing sequences will be discussed.

INTRODUCTION

The MOX Fresh Fuel Package (MFFP) will be utilized to transport MOX fresh fuel assemblies via a Safeguards Transporter (SGT) from the MOX Fresh Fuel Facility (MFFF) to the Mission Reactors. Auxiliary equipment to allow for the loading, unloading, and transport of the fuel assemblies are required. Many aspects of this equipment involve "first of a kind" evolutions. Figure 1 delineates the typical "load and unload" cycle for the fuel assemblies and the auxiliary equipment utilized.

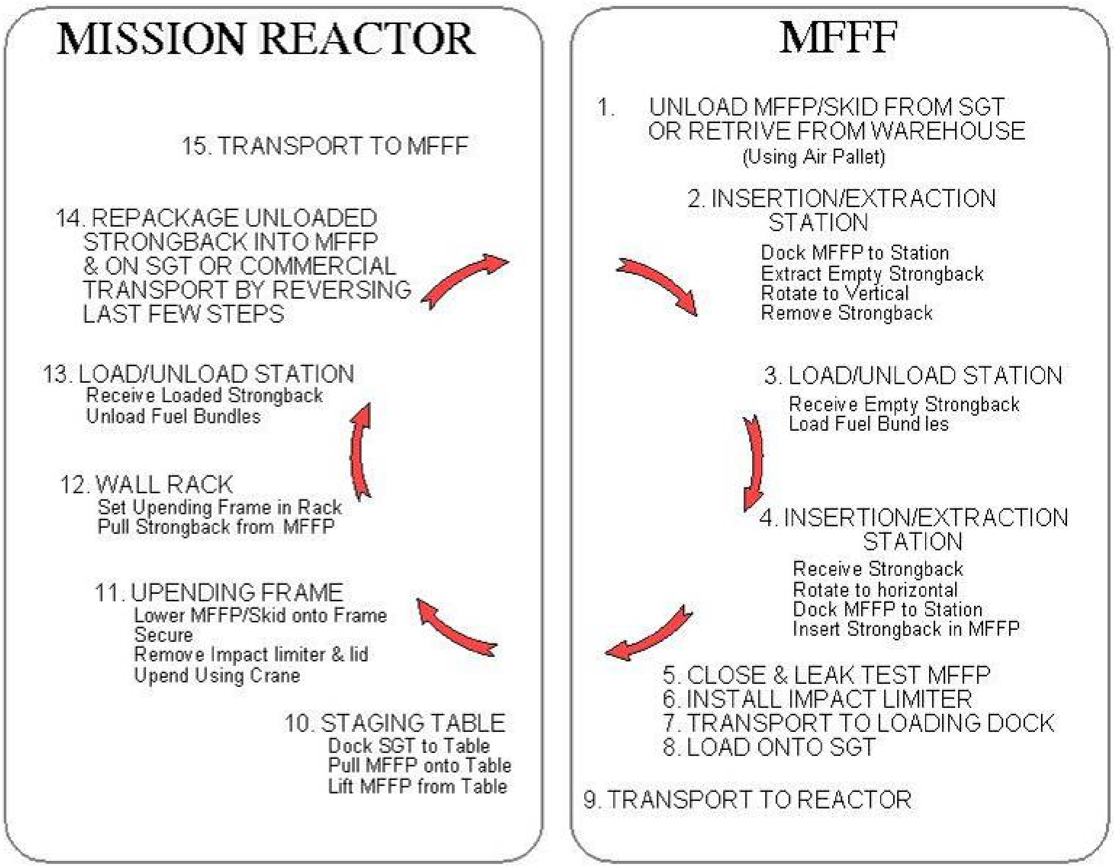

Figure 1. Auxiliary Equipment Typical "Load/Unload" Cycle

The equipment that comprises the auxiliary equipment is listed below:

1. Insertion/Extraction Station
2. Load/Unload Station
3. MFFP Skid
4. Upending Frame and Wall Rack
5. Air Pallet
6. Dummy Fuel Assembly and Rack
7. Strongback Lift Tool
8. Strongback Top Plate Lifting Fixture
9. MFFP Handling Lift Device
9. MFFP Lid Handling Fixture
10. Staging Table

DETAILED DESCRIPTION OF MAJOR EQUIPMENT

The major pieces include (items 1-5 listed above): the Insertion Extraction Station, Load Unload Station, MFFP Skid, Upending Frame, and Air Pallet. The remaining pieces (items 6-10) support these components with respect to transferring or storing various items except the dummy fuel assemblies. These assemblies are designed to balance the weight of the MFFP in the case of shipping less than 3 actual fuel assemblies.

Insertion/Extraction Station

Due to head height clearance in the MFFF, vertically loading of the MFFP is not permitted. The insertion extraction station (Figure 2) allows for the horizontal loading and unloading of the MOX fuel assemblies from the MFFP. This station is required to align with the MFFP to allow for a transfer of the Strongback carrying the fuel assemblies either into or out of the MFFP.

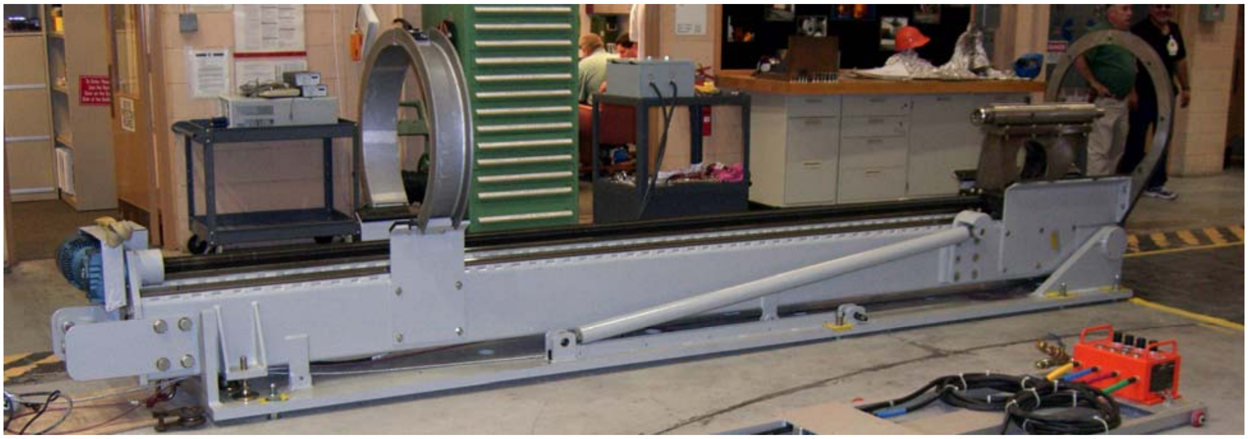

Figure 2. Insertion Extraction Station

The Insertion/Extraction Station is comprised of a steel support box and an electric driven ball screw assembly. A swing attachment assembly serves as the connection point between the ball screw assembly and the Strongback. The Strongback holds the fuel assemblies and is either inserted or removed from the MFFP by this station. This station is rotated vertically to load the Strongback and is rotated down to allow for alignment with the MFFP.

Load/Unload Station

The Load Unload Station (Figure 3) accepts the MFFP Strongback to either load the fuel assemblies or unload them. The Strongback can hold up to three MOX Fuel Assemblies. This station allows for the loading of the fuel assemblies at the MFFF and unloading of the fuel assemblies at the Mission Reactors.

Figure 3. Load/Unload Station

The Load/Unload Station is comprised of 457 cm (180 inch) support column, girth arms, and a turntable. The girth arms and top piece allow the Strongback to be placed vertically into the station safely. The turntable allows for rotation of the Strongback for loading and unloading of fuel.

Upending Frame

The Upending Frame (Figure 4) is utilized at the Mission Reactors to allow for vertical unloading of the MFFP at the Mission Reactors. The MFFP and skid arrive at the Mission Reactors in a horizontal position. The MFFP is placed on the Frame and is rotated to the vertical position. The skid is held in place by both ball pins and straps.

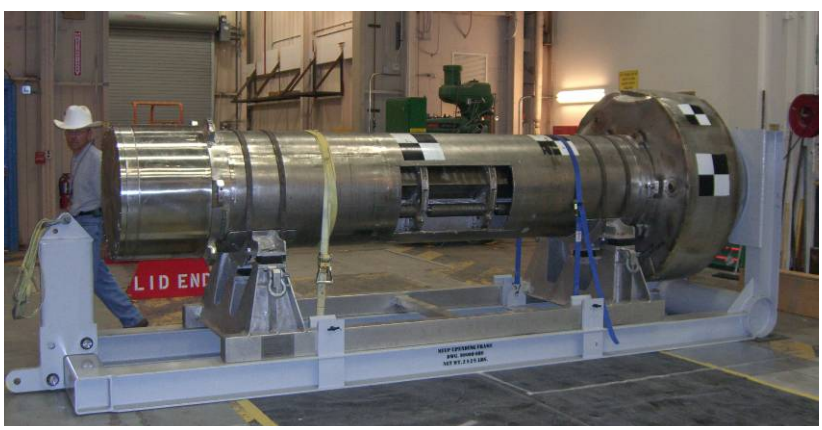

Figure 4. Upending Frame with MFFP Test Unit Loaded

The Upending Frame is comprised of a rotating lift arm, fabric straps, and an I beam structure. The upending frame was subjected to a load test of 111 kilonewtons (24,750 pounds).

MFFP Skid

The skid is utilized to transport the MFFP at all times. Due to the weight constrictions of the Safeguards Transporter (SGT), the skid is fabricated from aluminum. The MFFP is strapped to the skid by metal bands. Typically the skid and MFFP are treated as one assembly and would only be separated for maintenance purposes.

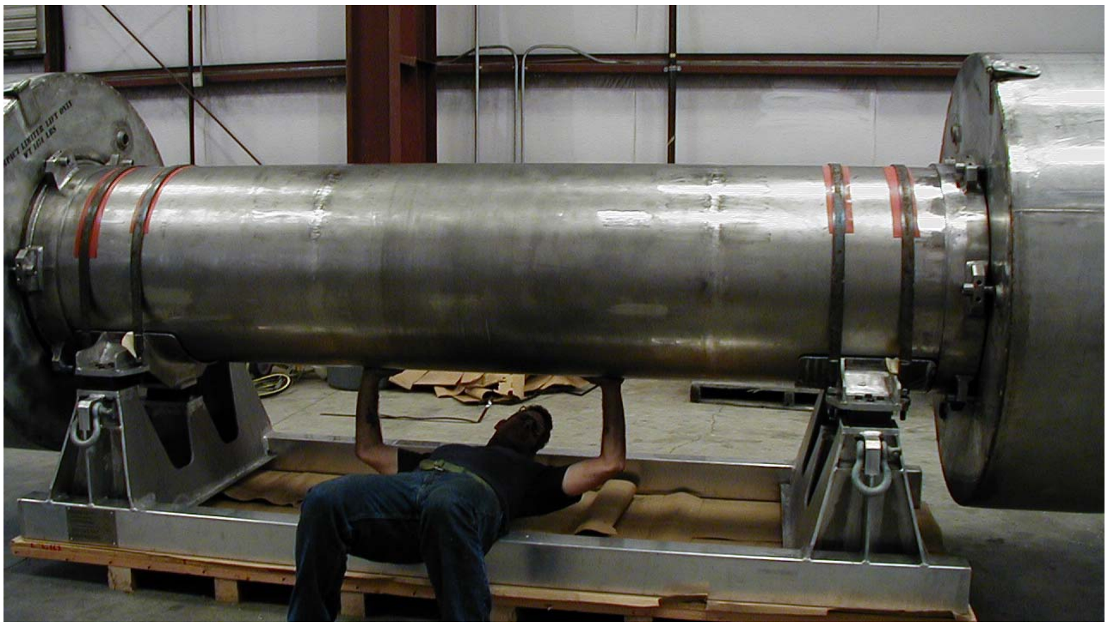

Figure 5. Skid with MFFP attached

Air Pallet

The air pallet is used to position the MFFP within the SGT trailer without damaging the trailer flooring. In addition, the air pallet will be utilized to move the MFFP throughout the MFFF. It will levitate the MFFP and skid approximately 0.635 cm (¼ inch) off the surface. The surface is required to be smooth, clean, and level.

For ease of handling, the air pallet is fabricated out of aluminum. There are four rubber air casters. These casters are controller by one main unit. 310-345 kilopascals (45-50 psi) of air is required to levitate the air pallet with a 6622 kilogram force (14,600 lbs) load. 689 kilopascals (100 psi) facility air with the appropriate volumetric volume rate is required for proper operations. Each of the four air casters can be controlled individually. This feature allows for balancing an uneven load.

Figure 6. Air Pallet

TESTING

Testing Facility

The MFFP auxiliary equipment testing was completed at Sandia National Laboratories in building 6360. Building 6630 is located inside of Technical Area III at Sandia National Laboratories, New Mexico. The building is equipped with a full capability machine shop, electronics laboratory, highbay, records storage facility and office space. The high bay has an overhead crane that is capable of moving full-scale casks and other heavy objects within the laboratory area. Work performed within the high-bay is done to support cask certification testing operations such as installation of accelerometers, thermocouples, and conducting pre- and post-test measurements. The building operations also support the set up and maintenance of the Mobile Instrumentation Data Acquisition System (MIDAS), an NQA-1 certified data collection trailer that is used for the collection of data during structural and thermal testing operations.

Basis for Testing

Each component was evaluated for safety, ability to complete stated task, reproducibility of motion, ease of use, and interfacing with other components. In addition, each major sequence was timed to aid in ascertaining both ALARA and production issues [1].

Test Findings for the Major Equipment

Table 1 below lists the major findings for this equipment from the testing.

Table I. Major Findings from Testing

Component	Finding
Insertion Extraction Station	It is necessary to utilize an onboard upending mechanism instead of MFFF crane due to over Center of Gravity lift
Load Unload Station	Add alignment guides to aid in centering the MFFP Strongback
Upending Frame	Determine a new option for “tripping” the frame when transferring from horizontal to vertical.
Air pallet	Redesign console for ease of use
Skid	Evaluate the new dynamic criteria for the SGT

Dynamic Testing

The dynamic limitations of the fuel assemblies are 4 gs in the vertical direction and 6 gs in the lateral direction. To evaluate the effects of the interaction between the MFFP shell and the fully loaded Strongback, accelerometers were attached to appropriate locations on the Strongback.

During the extraction of the fully loaded Strongback, the fuel assemblies were exposed to a maximum acceleration of 2.5 gs in the lateral direction and 2.6 gs in the vertical direction. During the insertion of the fully loaded Strongback, the fuel assemblies were exposed to a maximum acceleration of 2.7 gs in the lateral direction and 1.9 gs in the vertical direction.

Though these readings are acceptable, the dynamic reaction of the fuel assemblies can be lowered by decreasing the speed of the insertion extraction station motor. In addition, the values are considered conservative due to the irregularities in the refurbished Strongback and MFFP shell.

Timing

The major evolutions were timed to aid in the MFFF Operations in ascertaining ALARA objectives and production throughput. Initial observations that can be deduced from this data include:

1. The general loading of three fuel assemblies (steps 1 through 8 in Figure 1) at the MFFF will take approximately 323 minutes.
2. The general unloading of the three fuel assemblies at the Mission Reactor (steps 10 through 13) will take approximately 226 minutes.
3. The objective of aligning the MFFP with the insertion extraction station can be achieved in less than 20 minutes.

CONCLUSION

Overall, the MFFP Auxiliary Equipment performed well. The key issue of horizontal loading and unloading of fuel assemblies was successfully demonstrated. The dynamic results showed that the fuel assemblies can safely be handled by the insertion extraction station. In addition, the vertical unloading at the Mission Reactors was acceptable. Though the air pallet was successfully operated, the challenge of “air hose management” should be taken into consideration when determining the trade off between crane support and air pallet usage. Also, it was demonstrated that the SGT loading will be physically challenging due to the tight operating area within the SGT trailer and the number of tie down chains required. The timing of the steps will aid both ALARA and production planning.

REFERENCE

1. A. Ross, F. Yapuncich, “Factory Acceptance Test for the MOX Auxiliary Equipment”, FT-008, revision 1, Packaging Technology, (2007).