Bradley Loftin and Glenn Abramczyk
Savannah River National Laboratory

Design of a Cask for Onsite Transfer of Fuel Targets at the Savannah River Site

Abstract

The Savannah River Site (SRS) is currently planning to recover and process the 65 Mk-18A fuel targets, currently in storage in the L-Reactor Disassembly Basin (L-Basin), in order to recover rare isotopes they contain for which there is currently no practical production method. The Savannah River National Laboratory (SRNL) and the Oak Ridge National Laboratory (ORNL) have been tasked with developing a method for recovery of these isotopes. The first step of the recovery plan requires relocating the Mk-18A fuel targets from the L-Basin to the SRNL Shielded Cell facility for initial processing. A new, onsite only SRS transfer cask is being designed for this purpose. This paper provides a brief history of the Mk-18A fuel targets. It also discusses the requirements for onsite transfers at the SRS and the need for and the details of the new cask design.

History

The Savannah River Site operated five production reactors in support of United States nuclear defense programs producing mainly plutonium and tritium. However, there were a few cases where multi-year irradiation campaigns placed special targets in the core of production reactors for scientific research programs and in some cases for extended periods of time. One such campaign, begun in 1969, was a high-flux campaign to irradiate ^{242}Pu to produce ^{252}Cf. The initial irradiation ended 15 months later, but 65 of the Mk-18A targets remained in the reactor core until discharged in 1979.

The extended high-flux irradiation of the Mk-18A targets resulted in various rare isotopes being produced in the target. Some of these isotopes include ^{244}Cm, ^{246}Cm, ^{248}Cm, and ^{244}Pu. Of particular interest is the ^{244}Pu since it is virtually impossible to replicate this production, at this same scale, using existing high-flux reactors and, since the early 1990s, the reactors at SRS have not been in production nor operated. Thus, it was decided to explore options for recovery of these targets to preserve the valuable isotopes contained within them.

The Savannah River National Laboratory and the Oak Ridge National Laboratory collaborated on a study to determine the best way to recover the valuable isotopes from the Mk-18A targets. That study concluded that the Mk-18A targets could be processed into plutonium oxide and an oxide containing americium, curium, and other fission products in the SRNL E-wing Shielded Cell facility and then transferred to ORNL for further refining and separation. In order to begin the processing of the targets, they must be transferred across the SRS from their current storage location within the SRS L-Reactor Basin (L-Basin) to the SRNL Shielded Cell facility.

Onsite Transportation at the Savannah River Site

Transportation of radioactive materials completely within the boundaries of the SRS is referred to as a transfer. Transfers are completed within the requirements and parameters outlined in the SRS Transportation Safety Document (TSD). The TSD provides relief from the requirements for transportation of radioactive materials found in 49 CFR and 10 CFR based on restricted access to the SRS and is specifically allowed via Department of Energy Orders. The Mk-18A targets contain more than 1 A_2 of contents per 49 CFR and would be required to be shipped, in commerce, in a Type B package. The relief given by the TSD allows radioactive material to be transferred at the SRS in packaging that does not incorporate some of the design requirements and parameters found in 49 CFR and 10 CFR.

10 CFR 71.73 requires a Type B radioactive material package to be tested to withstand an 850°C fully-engulfing pool fire. Since this fire event can be mitigated via controlled access and roadblocks at the SRS, packagings may be designed without thermal insulating materials in order to save costs, weight, size, etc. Additionally, 49 CFR 173 and 10 CFR 71 require packages to meet certain dose requirements for shipment in commerce. These requirements are typically met in order to keep harmful radiation from the public. Per the TSD, the SRS radiological control manual provides the dose and contamination requirements that must be met for onsite transfers. Structurally, Type B packages are required to withstand a 30-foot drop and, for lightweight packages, a 30-foot crush, however, many fuel casks are too heavy to require a crush. 10 CFR 71 also specifies a maximum leakage rate that must be maintained after the accident sequence in 10 CFR 71.73. At the SRS, there is not a credible drop of 30 feet. Thus, while in transfer, vehicle speed is limited to reduce any impact that would equal the energy from a 30-foot drop. Additionally, release of materials onsite is based on DOE release criteria. The TSD allows these reliefs from the CFR, thus designs for onsite-only packages can be significantly less intricate and much more inexpensive than a package designed to the requirements found in 10 CFR 71.

Cask Design

As previously discussed, a cask to be used only at the SRS may require fewer design features than a Type B package. However, that does not mean that the design is necessarily simple. Complexities associated with onsite transfer must still be met by the design. The main two criteria for this onsite design are (1) limiting the dose to the worker and (2) low energy accident conditions, such as a roll-over. However, onsite transportation comprises only part of the design requirements for the onsite cask. Both the shipping and receiving facilities (L-Area and SRNL) requested that the cask design operate seamlessly with existing equipment found in the respective facilities. Those parameters added additional complexity to the transportation design.

The Mk-18A target assembly is stored in the L-Basin in a double J-can configuration (Figure 1). The double J-Can holds the target in a vertical position in the basin. There is not a deep enough area in the transfer bay area within L-Basin to load the target vertically into a cask while maintaining adequate shielding from the water. SRS has been using a SRS cask design, the 70-Ton Cask, for target transfers from the reactors to the separations facilities for decades. L-Basin has existing infrastructure for loading targets into the 70-Ton cask horizontally. The Mk-18A cask has, therefore, been designed to load a target horizontally in a similar fashion to how the 70-Ton cask operates. Additionally, L-Area requested that the cask not contain closed areas where water could accumulate thus allowing basin water to drain out of the cask when removed from the basin.

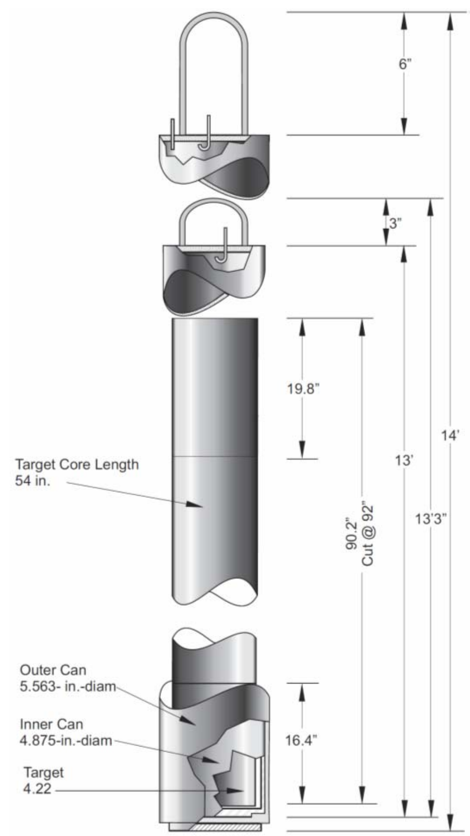

Figure 1—Double J-Can Configuration

The SRNL E-Wing Shielded Cells facility operates in a much different fashion. Currently the only way to introduce materials into the shielded cells is via removal of the cell covers or though specially designed ports near the ends of the cell block. The initial thought was that the Mk-18A was going to be inserted in to the cells via the top with multiple cell covers removed. Ultimately, however, the potential hazards from operating with multiple cell covers having been removed along with the potential for overworking the lifting crane led to a change in the design. The Mk-18A has been designed to be loaded into the shielded cells horizontally. The receipt area at SRNL has a lifting crane with a maximum capacity of 10 Tons. Thus the Mk-18A cask (or portion of the cask to be utilized for inserting the Mk-18A into the cells) has to weigh less than 10 Tons. Finally, SRNL required the cask to interface with the shielded cell facility so that ALARA principles were maintained during the unloading process.

The Packaging Technology and Pressurized Systems organization within the Research and Development engineering directorate of SRNL was tasked with developing the design of the cask. With the parameters and requirements set, design work began. It was decided that a cylinder, split longitudinally, would be able to operate similarly to the 70-Ton Cask and that once at SRNL, end plugs along the central axis could be removed to allow for insertion in to the shielded cells. This was the basic design for the central shield. However, a framework structure needed to be constructed to allow the package to rest on the superstructure within L-Basin that holds the lid of the 70-Ton Cask and will hold the upper portion of the Mk-18A cask.

The Mk-18A Cask Shield design incorporates concentric layers of stainless steel and 5% borated polyethylene. The stainless steel is used for structural integrity and for the shielding of gamma radiation. The 5% borated polyethylene is used for the shielding of neutron radiation. The entire shield is encapsulated in stainless steel and each end of the trough where the J-Can assembly sits in the shield is capped with a plug consisting of 5% borated polyethylene and lead (for gamma shielding) encapsulated in stainless steel. The structural framework is constructed of stainless steel. The overall size of the framework is approximately 20’(l) X 5’(h) X 4.5’(w). The shield weighs approximately 7.7 Tons and the Mk-18A Cask (Frame and Shield) weighs approximately 12.5 Tons.

Figure 2 shows a photograph of the 70-Ton cask in L-Basin (for reference), Figure 3 is a rendering of the Mk-18A cask design resting on the L-Basin superstructure, and Figure 4 is a rendering of the Mk-18A cask, opened, as it will be in L-Basin, with the J-Can assembly in the bottom portion of the cask.

Figure 2—70-Ton Cask Being Lowered into L-Basin

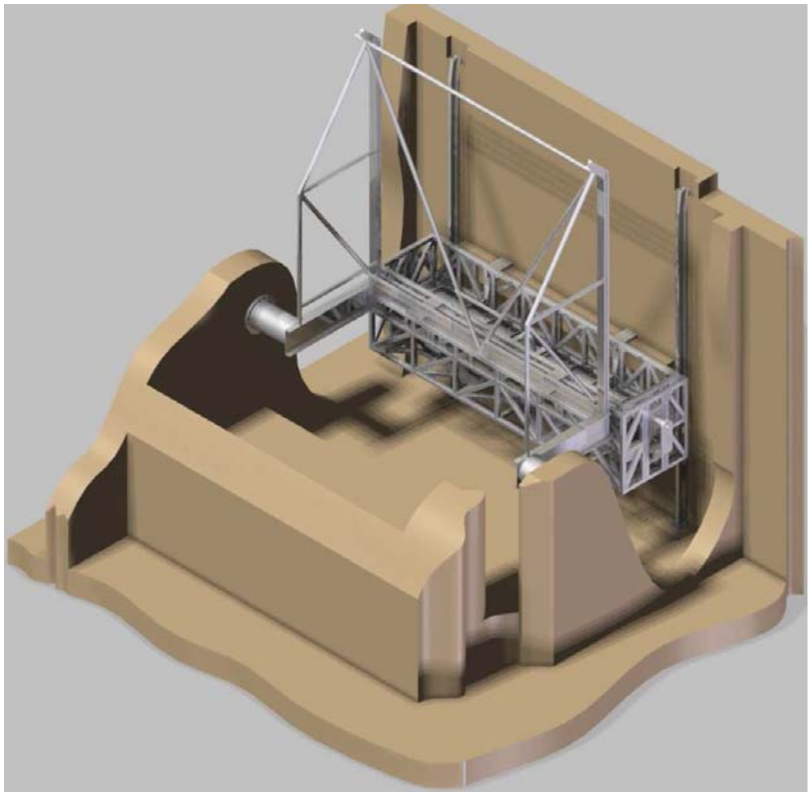

Figure 3—Mk-18A Cask (framework and shiel4d) on the L-Basin Superstructure

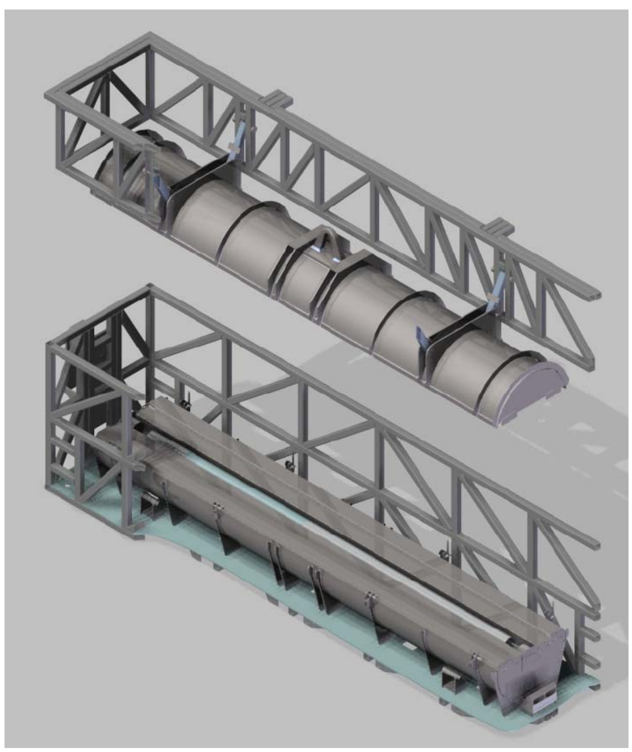

Figure 4—Mk-18A Cask with J-Can Assembly in Horizontal Position

The Mk-18A Cask once closed is placed onto a trailer for transfer to SRNL and wrapped in a contamination control bag. Figure 5 is a rendering of the trailer with the Mk-18A Cask on the deck and the contamination control bag in place. Once transferred to SRNL, the shield is then removed from the Mk-18A cask frame and placed on a transfer table to be readied for unloading at the SRNL Shielded Cell facility. The closed Mk-18A Cask shield is shown in Figure 6.

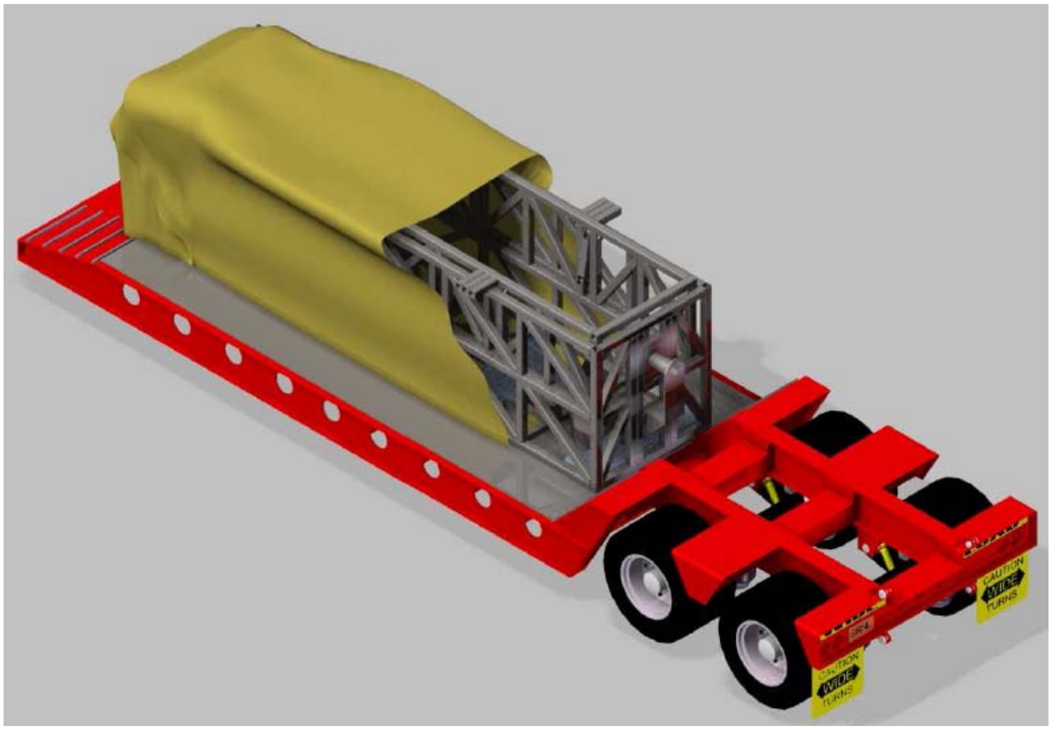

Figure 5—Mk-18A Cask on Transfer Trailer

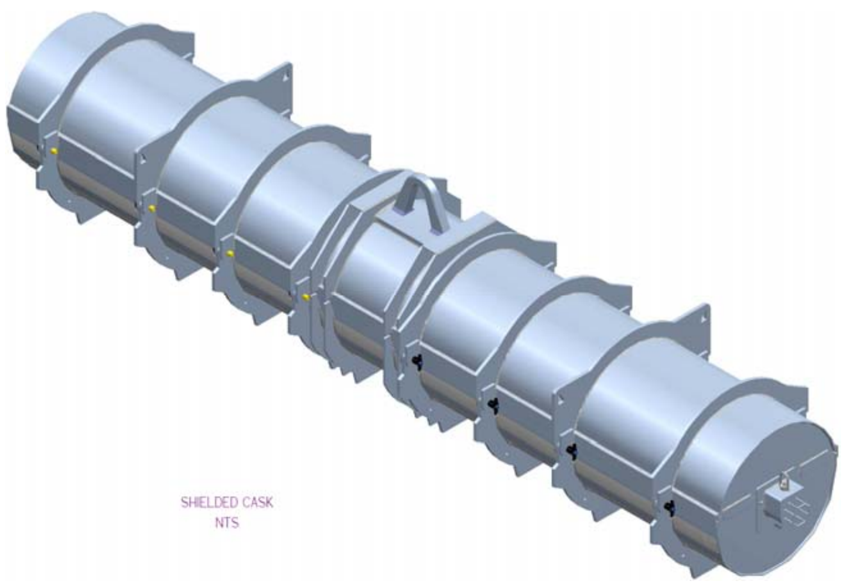

Figure 6—Mk-18A Cask Shield

Conclusions

The Mk-18A cask design incorporates features such that it can be utilized in both the L-Basin facility and the SRNL Shielded Cells facility as well as during transfer at SRS. Since this design is so versatile, it will save expense in both facilities where modifications would have been necessary to accommodate a new cask designed only for transportation. The Department of Energy will be able to recover rare and irreplaceable isotopes from the Mk-18A Targets with use of this cask.