Contract No:

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Disclaimer:

Fabrication of the Mk-18A Transfer Cask

Abstract

The Mk-18A transfer cask was designed for transfer of legacy Mk-18A target assemblies from the L-Basin Storage Area at the Savannah River Site (SRS) to the Savannah River National Laboratory (SRNL). SRNL needed to design a site-specific cask as all existing designs required extensive facility modifications to perform the necessary onsite shielding functions; in the L-Basin, during transfer, and at the SRNL. Once the design was approved, SRNL procurement requested quotes for its fabrication and awarded the contract to Petersen, Inc. in Ogden, Utah. This paper will provide a detailed look at how the Mk-18A will be used to accomplish the mission of recovering the Mk-18A target assemblies, it will briefly describe the process used at SRNL for procurement of radioactive material packagings, it will document and describe challenges in the fabrication of the cask, and it will explore requested design changes made by the fabricator and any impacts those changes have on the cask's ability to meet its performance requirements.

History

During the Cold War era, 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 during multi-year irradiation campaigns, special targets were placed into the cores of production reactors for scientific research programs. One such campaign, begun in 1969, was a high-flux campaign to irradiate Mk-18A ^{242}Pu Target Assemblies to produce ^{252}Cf. The initial irradiation and testing ended 15 months later, but 65 of the targets were not removed from the reactor core, where they remained until finally discharged in 1979.

The extended high-flux irradiation of the Mk-18A targets resulted in various rare isotopes being produced in these targets. These rare 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 its production, at this same scale, using existing high-flux reactors and the reactors at SRS have not been operated since the early 1990s. Thus, the National Nuclear Security Administration decided to explore options for recovery of these targets to preserve the valuable isotopes contained within them.

A collaborative study by the Savannah River National Laboratory (SRNL) and the Oak Ridge National Laboratory (ORNL) determined that the best way to recover these isotopes was for the Mk-18A targets to be processed into plutonium oxide and an oxide containing americium, curium, and other fission products in the SRNL E-wing Shielded Cell facility. The oxides would then be transferred to ORNL for further refining and separation. Since a cask capable of transferring the targets across the SRS from their current storage location within the SRS L-Reactor Basin (L-Basin) to the SRNL Shielded Cell facility for processing did not exist, a new onsite transportation cask was designed by SRNL Packaging Technology and Transportation Engineering.

Cask Design and 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. The Mk-18A targets contain more than 1 A_2 of contents per 49 CFR and would require a Type B package if shipped in commerce. 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. Thus, a new package was developed that incorporated features that allow the targets to be transferred from L-Basin to SRNL without requiring large, expensive shielded transfer systems in both L-Basin and in SRNL. The Cask, as seen in Figures 1, 2, and 3, consists of a Shield and a supporting Framework. The Cask will be loaded in the L-Basin similar to other existing designs and then be transferred onsite to SRNL. At the Shielded Cell Facility the Shield will be removed and placed on ancillary equipment for the mating with the cells for processing the Targets. The cask will then be reassembled and returned to L-Basin to initiate the next Target transfer.

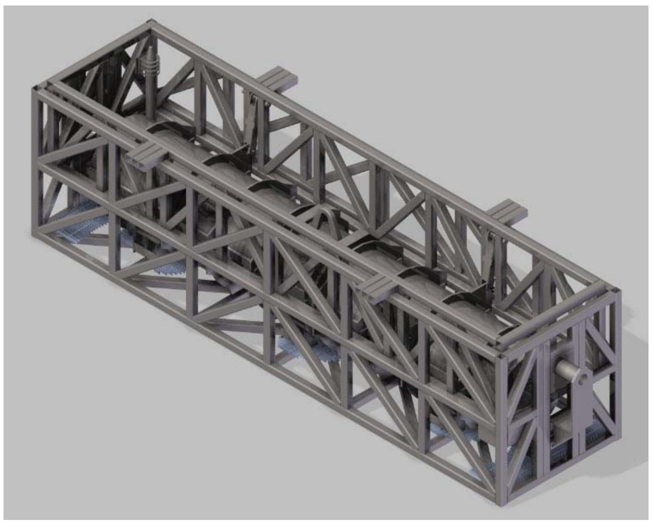

Figure 1 (Mk-18A Cask)

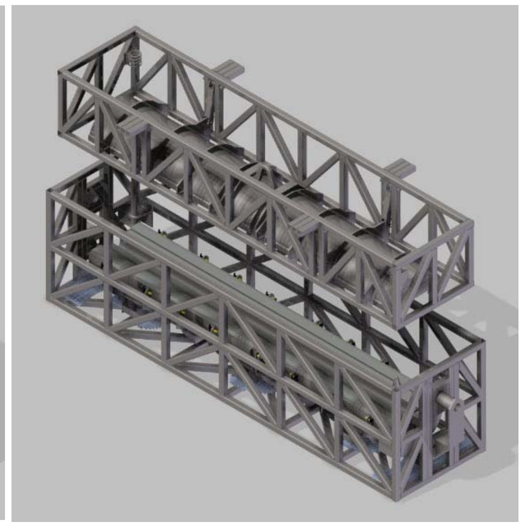

Figure 2 (Cask in L-Basin)

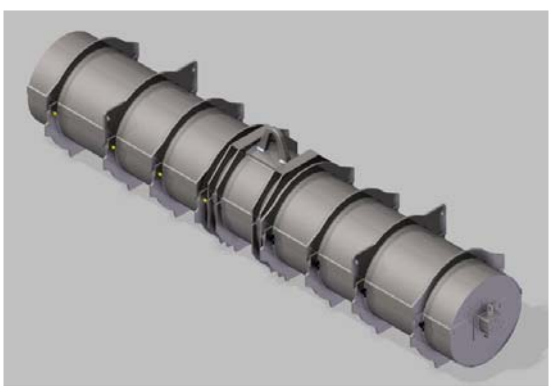

Figure 3 (Mk-18A Shield)

Procuring the Cask

Once the Mk-18A Transfer Cask final design was approved, the SRNL procurement agency began the process to award a contract for its manufacture. First, the final design is incorporated into a procurement specification. The specification provides details to a potential manufacturer on the specifics for fabricating the cask. These details include, but are not limited to, detailed drawings, ASME code requirements, AWS welding code requirements, testing requirements, and packaging and shipping (for delivery) requirements. Once the specification is finalized, a requisition is developed that includes the specification as an attachment and a rough estimate on how much the item to be procured will cost. This estimate is done to ensure that adequate funding is available before sending the item out for bid. Then, a buyer within SRNL initiates a bid package that is sent to potential Cask manufacturers. For the Mk-18A, three companies were identified and the SRNL buyer solicited bids from each. Two of the companies returned completed bids and the decision was made to award the Mk-18A fabrication contract to Petersen, Inc. in Ogden, Utah.

Fabrication Meetings, Successes, Challenges, and Design Deviations

Once the contract was awarded, SRNL personnel met with Petersen personnel to discuss the design and the expectations for the fabrication. As a result, Petersen was able to begin purchase of raw materials and develop a detailed schedule for the entire fabrication. Once Petersen had completed purchase of many of the raw materials, they were able to begin cutting pieces to size. Figures 4 and 5 show raw materials at Petersen after cutting (and some forming) but prior to fitting or welding. The outer frames of the Mk-18A along with the grating under the cask were relatively easy to fabricate, assemble, and join. These assemblies, the outer and inner frames, are shown in Figure 6.

Figure 4 (Borated Polyethylene pieces)

Figure 5 (Mk-18A Outer Shell pieces)

Figure 6 (Mk-18A Upper and Lower Frames)

The Shield assembly consists of two shielded “halves” that will encompass the Mk-18A target along with two plugs that will close the ends of the shielded assembly. When fully assembled, these components will provide adequate shielding for the workers in both facilities and during transportation. Although there are not many pieces to this assembly, the size and tight tolerances led to a few challenges during the Shield fabrication . It is important to discuss and understand some of these challenges as they are typical with a design of this size. First, the design drawings included in the initial bid package specified the entire outer skin of the Mk-18A top and bottom shield as one piece each. Petersen did not have a rolling machine that was large enough to accommodate a 17-foot long piece of ¼-inch stainless steel. Petersen requested to make the upper and lower sections in two pieces as seen above in Figure 6. This change led to structural concerns as the design was analyzed with one single steel piece. However, additional structural analyses were performed to show that there is more strength than required by the ASME code in the modified design (two pieces welded together) in lieu of a single piece. Once these pieces were joined, the rest of the shield began to take shape. The design incorporates two long gussets on the inside of both the top and the bottom shield assemblies. These gussets provide a pedestal, per se, to hold up the central, stainless steel shield forgings. These gussets were welded in place to the outer skins prior to welding the ribs on the outside of the skins. When the ribs were welded onto the outside of the skins, the heat within the weld zone expanded the metal which, during cooling, caused the contraction of the skin steel. This caused the gussets to buckle as seen in Figure 7. In order to “fix” this, the central shield forgings were welded onto the gussets, as designed. The straightness of the gussets was validated by welding in a piece of stainless plate that straightened the gussets as seen in Figure 8.

Other challenges were encountered as well during this fabrication; one of note was that the entire upper shield did not fit properly on the lower shield. A new cut-out was made on the lower shield to allow the pieces to assemble properly. Once this design change had been incorporated, the entire cask was ready for final inspection and testing.

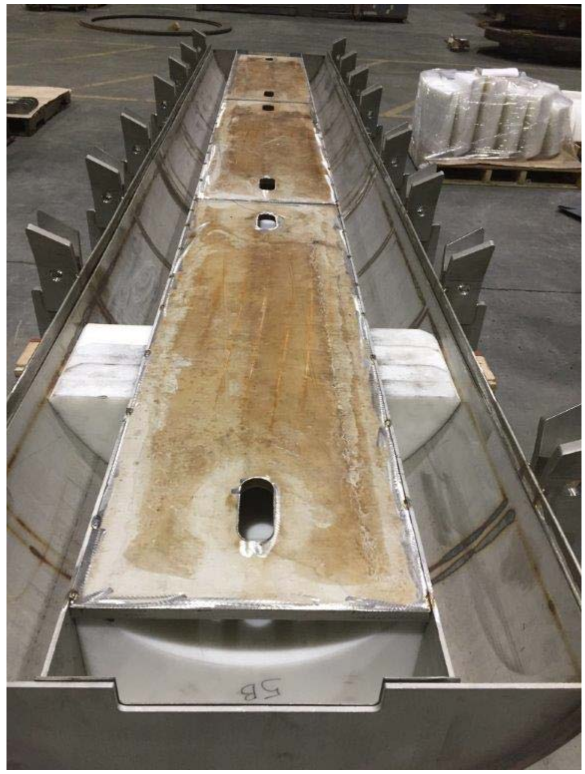

Figure 7 (Warped Gussets)   Figure 8 (Proof of Concept Straightening of Gussets)

Fabrication Successes and Finished Mk-18A Cask Assembly

The completed Mk-18A Cask is seen in Figures 9-13. Petersen provided expert manufacturing and completed the build without any major pieces having to be replaced or significant design changes approved via a "deviation" request. This allowed the Mk-18A Cask to be made nearly on schedule with the only slips in the schedule being due to paperwork transfers between SRNL and Petersen and the resources available for completion and acceptance/approval of the same. The completed Mk-18A Cask will be able to provide shielding for personnel while transferring the Mk-18A Target Assemblies at the SRS.

Figure 9 (Final Assembly)   Figure 10 (Completed Mk-18A Cask)

Figure 11 (Mk-18A Shield Removed from Frames)

Figure 12 (Upper Frame and Upper Shield Removed)

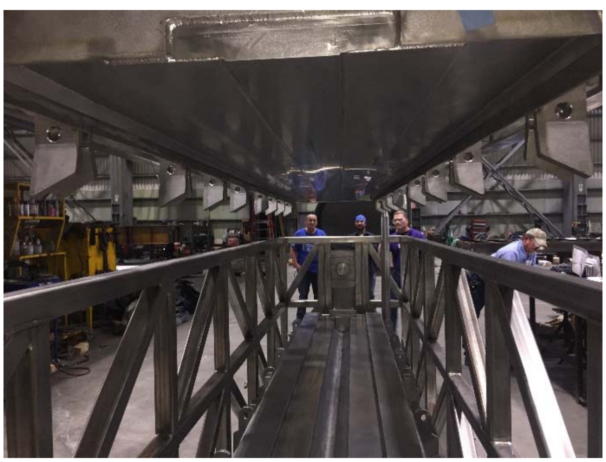

Figure 13 (Upper Frame and Upper Shield Removed)