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Packaging Plan for Mark-18A Plutonium Oxide

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National Nuclear Security Administration

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Nuclear Nonproliferation Division

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CONTENTS

1. INTRODUCTION

Mark-18A (Mk-18A) targets were irradiated at the Savannah River Site and have been in wet storage at the site since the 1970s. The Mk-18A Target Material Recovery Program has been established to recover the ^{244}Pu and heavy curium (≥50% ^{246}Cm and ^{248}Cm) in the targets at the Savannah River National Laboratory (SRNL) and ship the materials to Oak Ridge National Laboratory's (ORNL's) Radiochemical Engineering Development Center for programmatic use. Two products will be recovered from the Mk-18A targets for shipment from SRNL to ORNL: a plutonium oxide stream and an oxide material that will contain the americium, curium, and lanthanides. This document presents the plan for packaging of the plutonium oxide material for shipment and storage at ORNL.

2. BACKGROUND

Eighty-six Mk-18A targets were irradiated in a high-neutron-flux mode in the K-Reactor at Savannah River Site in the 1970s. Twenty-one targets were shipped to ORNL for processing at Radiochemical Engineering Development Center in the 1970s. The Mk-18A Target Material Recovery Program will address the 65 targets that remain at Savannah River Site. Under the program, the 65 Mk-18A targets will be retrieved from wet storage at the L-Basin at the Savannah River Site and processed to produce a plutonium oxide stream and an americium–curium–lanthanide oxide stream. The estimated plutonium portion of all 65 targets is shown in Table 1.

Table 1. Composition of the Plutonium Product (decayed to 10-1-22)[1].

Isotope	Mass (g)	Isotopic Mass %	Activity (Ci)
Pu-238	6.70E-01	0.10%	1.14E+01
Pu-239	3.89E-01	0.10%	2.41E-02
Pu-240	5.17E+02	86.10%	1.19E+02
Pu-241	3.52E+00	0.60%	3.87E+02
Pu-242	5.49E+01	9.20%	2.15E-01
Pu-244	2.40E+01	4.00%	4.32E-04
Total Pu	**6.00E+02**	**100%**	**5.18E+02**

[1] Sharon Robinson and Bradley Patton, *Preliminary Mark-18A (Mk-18A) Target Material Recovery Program Product Acceptance Criteria*, ORNL/TM-2016/527, Oak Ridge National Laboratory, Oak Ridge, TN, September 2016.

The Mk-18A targets will be processed in batches at SRNL, with the plutonium portion accumulated as solution and then precipitated and calcined to an oxide product. The solution from the initial target processed at SRNL will be calcined and shipped to ORNL. After that, the plutonium solution will be accumulated over approximately 1 year (likely three to six targets) and then precipitated and calcined to an oxide product and then shipped to ORNL.

2.1 PACKAGING PLANNING

In planning the packaging and containerization of the plutonium oxide product, SRNL requirements, transportation requirements, and ORNL requirements were considered. This plan refines the draft plan developed on August 31, 2021, which was revisited to look for opportunities to improve efficiency. The present plan meets all present-day requirements and eliminates repackaging operations at ORNL that were proposed in the 2021 draft. The major changes from the 2021 draft include the elimination of the 3:1

hydrogen-to-fissile material ratio because it is no longer a requirement in the most recent revision of 49 CFR 173.417, and replacement of the aluminum can overpack with a “food-pack can” (identified as an “isotope can” in this document) specified as an acceptable overpack container for the 9977 in 49 CFR 173.417. The latter also eliminates safety concerns of storage of materials in Cell F in aluminum containers.

2.2 PACKAGING CONFIGURATION

Purified plutonium solution will be collected from processing each target, and the solution will undergo precipitation and calcination. The resulting plutonium oxide will be placed into B-vials and stored in a glovebox at SRNL. Each B-vial has an internal volume of 8.25 cm^3 (see Figure 1 and Appendix A) and may contain ~10 g plutonium oxide. The loaded B-vials will be bagged out of the glovebox line approximately once per year (likely three to six at a time), and the bag will be placed in a second contamination control bag. The nested bags containing the B-vials will be placed into a 4 in. × 7 in. isotope can and packed with steel wool (see Figure 2 and Appendix B). The isotope can will be sealed for packaging using a can crimper.

Figure 1. B-vial.

Figure 2. Food-pack can (or isotope can).

The isotope can containing the nested plastic bags with the B-vials will be loaded into a 9977 shipping container for a Type B shipment to ORNL under the training sources content envelope 77C.15. Once at ORNL, the isotope can containing the B-vials will be removed from the 9977 shipping container and placed into a 6M shipping container for storage in Building 7930, Cell F. Around the time that ORNL packages the plutonium for storage in Building 7930, Cell F, the 9977 shipping container will be returned to SRNL to prepare for follow-on shipments (Figure 3). The follow-on shipment will be packaged as described above, with the possible exception that the plutonium may be stored in the same 6M container as a previous shipment to minimize storage space requirements in Cell F.

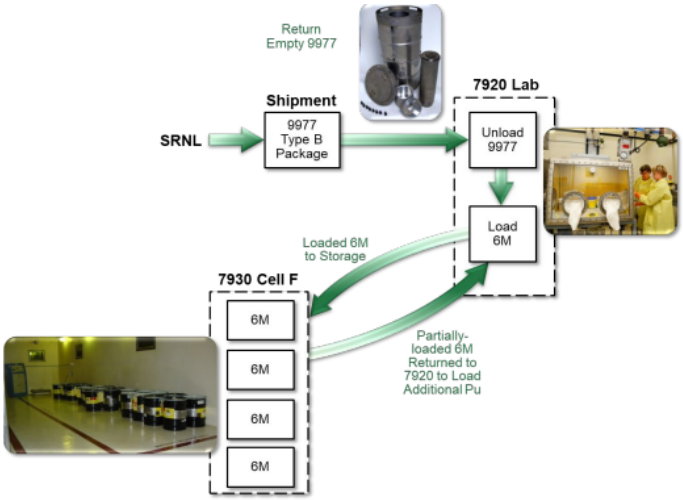


Figure 3. Shipping scheme for plutonium portion of Mk-18A shipments.

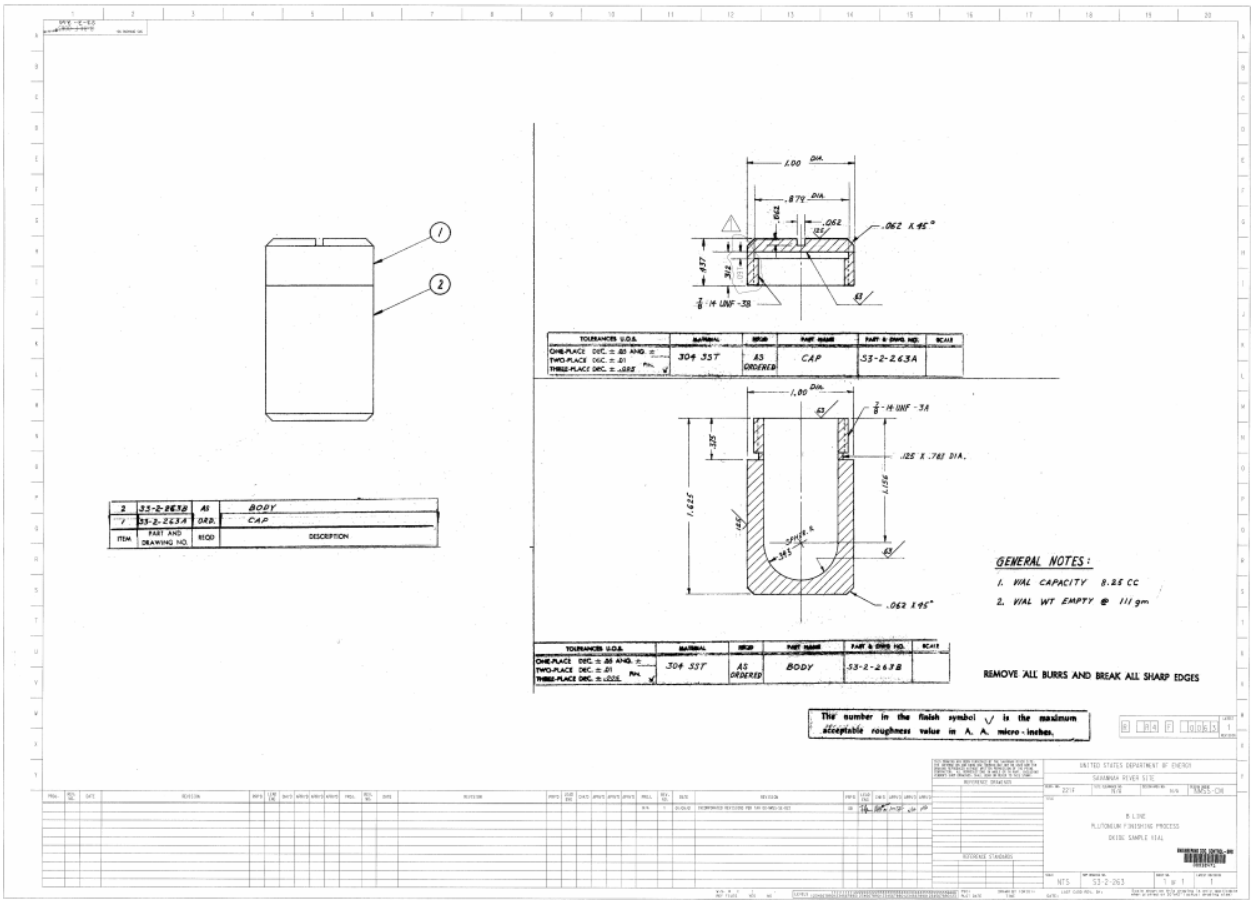
Overall, SRNL will be the shipper of record and will certify that each 9977 shipment meets Department of Transportation requirements and ORNL acceptance criteria before the shipment from SRNL to ORNL.

The Mk-18A materials will remain in the as-shipped containers for all ORNL on-site shipments, until opened and repackaged as outlined earlier in this document.

2.3 CONCLUSION

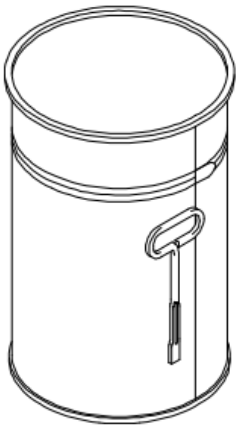
Plutonium from the Mk-18A target recovery program will be packaged in a collection of B-vials, two plastic bags, and an isotope can all inside a 9977 shipping container for a Type B shipment from SRNL to ORNL. Once at ORNL, the isotope can will be placed in a 6M storage container. Emptied 9977 shipping containers will be returned to SRNL to prepare for future shipments. These efforts will preserve valuable ^{244}Pu for future enrichment and use by the science and nuclear security communities.

APPENDIX A. B-VIAL DIAGRAM



APPENDIX B. ISOTOPE CAN OR "FOOD CAN"

COMPONENT INFORMATION (TEN-E Packaging Services Quality Control Audit)

ROUND METAL CAN				DRAWING
Manufacturer: Berlin Packaging, Bridgeville, PA				
Description:	1.5 Liter Round Metal Can with Key Opener			
Material:	Electrolytic Tin Plate			
	Body:	**Top:**	**Bottom:**	
Thickness:	0.010"	0.009"	0.010"	
Coating/Lining:	None			
Side Seam:	Welded			
Tare Weight:	156 Grams			
Capacity:				
• **Rated**	1.5 Liters			
• **Overflow**	1,447 Grams (48.91 oz.)			
Overall Dimensions:				
• **Diameter**	4-1/4"			
• **Height**	7"			
Markings (QC Audit):	None			

KEY OPENER		DRAWING
Manufacturer: Berlin Packaging, Bridgeville, PA		
Description:	Metal Key Opener Welded Onto Can	
Material:	Steel	
Tare Weight:	8.260 Grams	
Overall Dimensions:		
• **Length**	3-3/8"	
• **Width**	1-1/2"	
• **Diameter**	0.121"	
Markings (QC Audit):	None	