Development of Type A Transport Packagings - 17073[a]

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ABSTRACT

ORNL ships a wide variety of radioisotopes. Many of these are associated with the DOE Isotope Program and Office of Nuclear Materials Integration (ONMI) and can be shipped as DOT Type A quantities of material. The DOT Specification 6M Type B packaging previously used for many shipments at ORNL is no longer authorized. Most materials could be shipped in Type B packagings, but many of them can meet the requirements for shipping as Type A. As a result, ORNL is working with a packaging manufacturer to develop, test, and certify several Type A packagings. These include a 38 L (10 gal) Type A packaging primarily to be used for transport of Cf-252 sources, a 208 L (55 gal) Type A packaging primarily to be used for transport of americium/curium/lanthanide oxide materials recovered from high-burnup targets, and a Type A packaging for transport of irradiated actinium targets. These are being developed with consideration for both gamma and neutron shielding for contents reading up to 5000 R/h.

INTRODUCTION

ORNL has a need for new Type A shipping packaging. This need is the result of DOE programs generating new materials that need to be shipped, and previously used shipping packagings are no longer authorized. These materials could be shipped in Type B packagings, but many of them can meet the requirements for shipping as Type A when shipped as special form material. Since the costs for procurement and associated transport costs of Type A packagings are generally less than for Type B shipping packagings, ORNL is developing a new Type A packaging primarily for use by three DOE programs.

The DOE Office of Science's Nuclear Physics Isotope Development and Production for Research and Applications program (DOE Isotope Program) strives to make critical isotopes more readily available for energy, medical, and national security applications and for basic research [1]. Among these isotopes is actinium-225 (Ac-225), an isotope that may be a promising treatment for targeting many forms of cancer, including leukemia and melanoma. Ac-225, a short-lived alpha emitter,

quickly releases a high amount of energy in the form of alpha particles that can only travel short distances. As such, Ac-225 has the ability to destroy targeted cancer cells without destroying healthy surrounding tissue. Traditionally, Ac-225 has been produced through the natural decay of thorium-229 (Th-229) from uranium-233, which is not readily available and has an extremely long half-life or slow rate of decay. In collaboration with BNL and LANL, ORNL has been developing an accelerator-based capability to demonstrate scale-up of Ac-225 production. The national laboratories are working to develop a new Ac-225 production approach in which readily available thorium metal targets are bombarded with high-energy protons. New shipping packagings are needed to transport the proton-irradiated Th-232 targets from LANL and BNL to ORNL where the Ac-225 is separated and evaluated. The targets can be shipped in a Type A packaging when shipped in special form.

The DOE Californium-252 (Cf-252) Loan/Lease Program (formerly part of the Cf-252 Market Evaluation Program) was created in the 1960s to develop the market for portable Cf-252 neutron sources for applications in neutron radiography, neutron activation analysis, and therapeutic medicine. The Cf-252 Loan/Lease Program was established to provide low-cost access by government agencies, qualified government contractors, and universities to Cf-252 sealed sources for educational, research, and medical applications. Funding for the program ended in 2008, and ONMI established the Cf-252 Loan/Lease Program Closeout program in 2014. Under the Closeout program [2], ORNL is recalling ~110 sealed sources from various locations around the United States and preparing them for disposal if they are not needed by other DOE programs. Each sealed source originally contained less than 1 µg up to milligram quantities of californium oxide (Cf_2O_3). Older sources also contain measurable amounts of Cm-248, which is created by the radioactive decay of Cf-252. All the sealed sources can be transported in a Type A packaging, and a significant fraction of the sources could be shipped in smaller Type A packages that are much easier to handle than those presently available.

The ONMI also established the Mk-18A Target Material Recovery Program (MTMRP) in 2015 to preserve the world's supply of Pu-244 and heavy curium [3]. Eighty-six Mk-18A targets were irradiated in a high-neutron-flux mode in the K-Reactor at SRS in the 1970s. The high neutron irradiation resulted in Mk-18A targets with unique contents. The majority (>80%) of the existing global inventory of Pu-244 is contained in the Mk-18A targets which are in wet storage at SRS. The total inventory in the Mk-18A targets is about 24 g of Pu-244 in several hundred grams of plutonium, primarily Pu-240. The Mk-18A targets also contain ~650 g of heavy curium, which is ~80% of the nation's heavy curium (≥50% Cm-246) inventory. Under the MTMRP, the Mk-18A targets will be retrieved from wet storage and processed to produce two products: a plutonium-rich oxide stream and an oxide material which will contain the americium, curium, and lanthanides. These materials will be shipped to ORNL to store the recovered materials and to provide any additional processing required to prepare them for future beneficial use. The americium/curium/lanthanide oxide material can be shipped in a Type A packaging when shipped in special form.

ORNL is developing three new Type A shipping packagings to meet the needs of these DOE programs. The Type A packagings for the Mk-18A material and Ac-225 targets are being developed for shipping materials in special form. The Cf-252 Type A package is being developed for shipment of material in normal form. For domestic shipments, 49 CFR 173.476 allows DOE shippers to self-certify the special form capsule's compliance with the development of a safety analysis in accordance with the applicable transportation regulations without a DOT-IAEA Certificate of Competent Authority being issued. These new Type A packagings are being self-certified for the applications described above. However, the packaging is being developed with the flexibility to potentially meet other user needs. This paper covers the evaluation, development, assembly, and certification of these Type A packagings.

DESCRIPTION

Type A packagings, such as the S100 and S300, have been used to ship sealed and leaking sources and oxide powders containing alpha-emitting isotopes in special form. The general design concept for these packagings is being used to develop the new configurations of Type A packagings for use at ORNL.

A Type A packaging is being designed to ship irradiated Ac-225/Th-232 targets in special form. The concept for packaging is shown in Fig. 1. It is envisioned that the primary shielded packaging with overall dimensions of ~30 cm (12 in.) diameter by 51 cm (20 in.) high will contain ~2.5 in. of DU shielding encased in stainless steel. The packaging is expected to weigh ~400 kg (875 lb). The inner cavity of the packaging will be ~13 cm (5 in.) diameter and 32 cm (12.75 in.) high. It will accommodate a 7.6 cm (3.0 in.) diameter by 30 cm (11.75 in.) high LANL Model II special form capsule. It is being developed for a target at ~300 mCi Ac-225 content. The DU shielded packaging will be placed in a drum for certification as a Type A package.

Fig. 1. Proposed Type A packaging for irradiated Ac-255:
Type A packaging concept on left; Model II special form capsule on right.

A Type A packaging has been designed and fabricated for shipment of Cf-252 sealed sources. The packaging is shown in Fig. 2. It is a 38 L (10 gal) drum unit containing ~2.5 cm (1 in.) of lead shielding and ~12.7 cm (5 in.) high density polyethylene (HDPE) shielding. The packaging weighs ~50 kg (130 lb) and is light enough to be moved with a hand cart. The cavity of the packaging is ~3.8 cm (1.5 in.) diameter and 10 cm (4 in.) high. It was developed for 3-4 µg Cf-252 and measurable amounts of Cm-248, which is created by the radioactive decay of Cf-252. The maximum dose on contact reaches ~50 mrem/h at 3 µg Cf-252, and 200 mrem/h at about 12 µg. If the packaging holds an older source that emits gamma radiation, then the upper limit for Cf-252 falls by half.

Fig. 2. Proposed Type A packaging for Cf-252 Sealed Sources:
Type A packaging on left; Cf-252 sealed sources on right.

A Modified S300 Type A packaging is being developed that will contain both gamma and neutron shielding for the Mk-18A americium/curium/lanthanide material. A concept for a Modified S300 Type A packaging is shown in Fig. 3. It is envisioned that the 208 L (55 gal) drum unit will contain ~6 cm (2.4 in.) of lead shielding and ~13.7 cm (5.4 in.) HDPE shielding plus a 1.3 cm (0.5 in.) HDPE removable sleeve located inside the lead shielding. The packaging is expected to weigh ~440 kg (970 lb). The cavity of the packaging will be ~11.4 cm (4.5 in.) diameter (without the HDPE sleeve) and 22 cm (8.5 in.) high. It will accommodate a 6.4 cm (2.5 in.) diameter by 18 cm (7 in.) tall Model III special form capsule and is expected to reduce a radiation dose of ~5,000 R/h on the surface of the special form capsule to below dose limits for the Type A package for exclusive use domestic ground shipments. An evaluation for the increase of radiation is being performed per DOT 173.412 (j) (2), which is defined as 20% for international use.

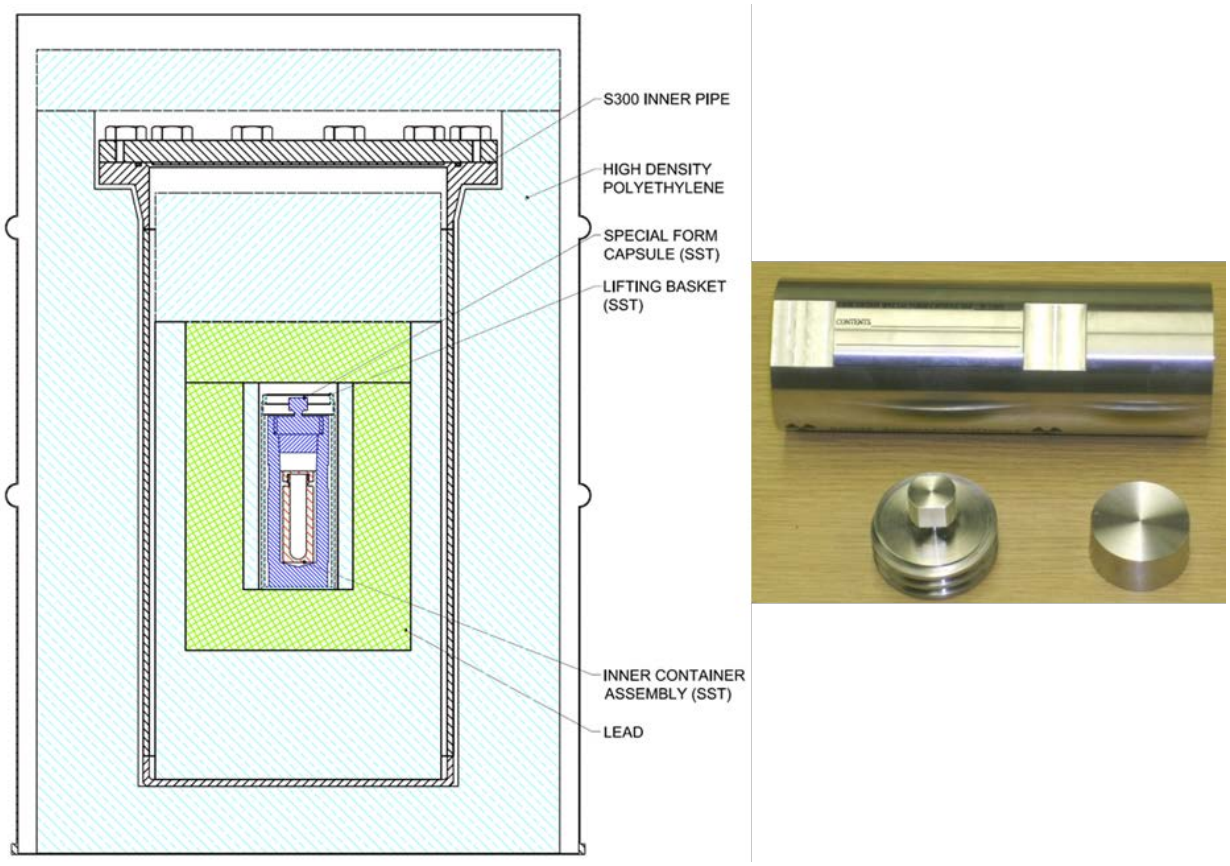

Fig. 3. Proposed Type A packaging for materials recovered from high-burnup targets: Type A packaging concept on left; Model III special form capsule on right.

DISCUSSION

A preliminary concept of the DU shielded packaging has been completed for the shipment of irradiated Ac-225/Th-232 targets and reviewed for operability at the primary hot cell facilities. A procurement for the fabrication of the DU shielded packaging is in progress. The design of the final enclosure (overpack) and certification testing as a Type A package will be included in the procurement specifications. It is anticipated that three to four months will be required for the final packaging availability for a test shipment with an irradiated target.

Four of the 38 L (10 gal) Type A packagings developed for shipment of Cf-252 sealed sources have been fabricated at a cost of ~$3,000 each. The Type A packaging was developed from a Skolnik Industries packaging. The new configuration was tested at Skolnik and has a certification of compliance/conformance from Skolnik. These packagings have been used to transport 15 sources from their loan holder locations to ORNL. The packagings are expected to be used to ship >90% of the Cf-252 sources that are loaned out to non-DOE facilities. These packagings can be moved with a hand cart and are much easier to load/unload and transport than the larger Type A packagings presently available to the Cf-252 Loan/Lease closeout program.

The development of the 208 L (55 gal) Type A packaging for shipment of americium/curium/lanthanide oxide materials recovered from high-burnup targets was completed in 2016, and prototypes of the packaging are presently being fabricated/assembled. It is estimated that the modified S300 Type A packaging and the Model III special form capsule will be completed for certification for the Mk-18A americium/curium/lanthanide oxide material in 2017.

CONCLUSIONS

ORNL is developing, assembling, and certifying, along with the drum manufacturer, several Type A packagings, including a 38 L (10 gal) Type A package primarily to be used for transport of Cf-252 sources, a 208 L (55 gal) Type A package primarily to be used for transport of americium/curium/lanthanide oxide materials recovered from high-burnup targets, and a Type A package for transport of irradiated actinium targets. They are being developed with consideration for both gamma and neutron shielding of contents reading up to 5,000 R. The 38 L (10 gal) packaging has been in use for approximately a year, and the other two packagings are expected to be certified for use within a year.

REFERENCES

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