Plutonium-238 Supply Project: Target Design and Scale-up. Robert M. Wham, Oak Ridge National Laboratory, P. O. Box 2008, Oak Ridge, TN 37831

Abstract: The current supply of plutonium-238 (^{238}Pu), used to power deep-space missions for the National Aeronautics and Space Administration (NASA), can only support a limited number of future missions. A new supply chain is planned using existing reactors at Oak Ridge National Laboratory (ORNL) and Idaho National Laboratory (INL) and existing chemical recovery facilities at ORNL. Validation and testing activities have been conducted over a 2 year period to provide data for scale-up to production. Target design, qualification, target fabrication, and irradiation of full-length targets have been accomplished. Post-irradiation analysis has been conducted to support the safety analysis of the targets.

Keywords: ^{238}Pu, ^{237}Np, reactor irradiation, chemical separations

Introduction: The DOE national laboratories build radioisotope power systems, which are supplied to NASA for use in specific space mission activities. Decay heat from plutonium-238 dioxide pellets fuel the radioisotope power systems that provide electrical power and heat for NASA spacecraft. The United States no longer has a domestic supply of ^{238}Pu. DOE plans to reestablish the infrastructure between now and 2018.

Plutonium-238 production has been analyzed using existing DOE facilities. Two reactors, the High Flux Isotope Reactor (HFIR) at ORNL and the Advanced Test Reactor (ATR) at INL, can irradiate sufficient neptunium oxide (NpO_2) to produce ~1.5 kg of plutonium product per year. The hot cell facility in the ORNL Radiochemical Engineering Development Center (REDC) can process approximately 1.5 kg of plutonium per year (based on five campaigns of approximately 100 targets per campaign with each campaign yielding 0.3–0.4 kg of plutonium product). This paper describes the tests conducted to qualify full-length targets for irradiation.

Target qualification. The irradiation test program consists of multiple phases that provide an incremental approach intended to reduce the risk of target failure during testing.

Single-pellet irradiations. Single-pellet targets have been designed to test various aspects of pellet dimensional changes and pellet-clad interaction (PCI), and are short capsules placed into a specially designed holder, as shown in Figure 1. The targets are not arranged in arrays that will cause local flux depression and therefore provide excellent information on performance at fluxes that are expected in HFIR's removable beryllium positions. Data from these single-pellet tests were used to qualify partially loaded targets.

Figure 1. Single pellets.

Partially loaded ^{237}Np target rod irradiations. Each of the irradiation target rods included multiple neptunium pellets in about 3 inches of active length. The targets were arranged in arrays of seven in specially designed holders.

Fully loaded ^{237}Np target rod irradiations. Each of the irradiation targets included the maximum number of neptunium pellets, resulting in about 20 inches of active length. The targets were arranged in arrays similar to those of partially loaded irradiations. See Figure 2.

Figure 2. Fully loaded test targets prior to irradiation.

Summary: Target fabrication has been scaled up by ~100× from single-pellet targets to full-length targets. The data collected to date indicates that the individual pellets tend to shrink after one cycle of irradiation and then swell slightly, returning to a volume similar to that measured before irradiation. Fission gas release was ~8–12% after two cycles, which yields acceptable pressures inside the target.

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