**Introduction:** The current supply of plutonium-238 ($^{238}$Pu), used to power deep-space missions for the National Aeronautics and Space Administration (NASA), is nearly exhausted. A new supply chain is planned using existing reactors at Oak Ridge National Laboratory (ORNL) and Idaho National Laboratory (INL) and using existing chemical recovery facilities at ORNL. Validation and testing activities are required to begin scale-up for future production. Target design qualification, target fabrication, irradiation, and chemical processing development tasks have begun in order to develop appropriate technology to supply the $^{238}$Pu needed by NASA.

**Keywords:** Plutonium-238 ($^{238}$Pu); Neptunium; NASA; DOE; Target Fabrication; Chemical Processing.

**Background:** Plutonium-238 contained in radioisotope power systems provides power for use in deep-space missions. Radioisotope power systems uniquely enable missions that require a long-term unattended source of electrical power and/or heat in harsh and remote environments. NASA has flown 26 such missions over almost 50 years [1, 2].

**Fig. 1. The infrastructure for production of $^{238}$Pu.**

Figure 1 shows the basic steps that are required to produce new $^{238}$Pu: (1) neptunium storage, (2) target fabrication, (3) target irradiation, and (4) chemical processing of irradiated targets to recover $^{238}$Pu. Target irradiation can be accomplished in existing reactors at the national laboratories. Target fabrication, target irradiation, and chemical processing are the functions that need to be reestablished. DOE has presented a plan to use existing reactors at ORNL and INL and processing facilities at ORNL, modified as needed to specifically produce $^{238}$Pu. This approach is viewed as the most cost-effective and timely means of reestablishing production at a rate that meets projected user needs. Figure 2 shows the functional steps required to produce $^{238}$Pu.

**Fig. 2. Approach for $^{238}$Pu Production and Recovery.**

An irradiation test program is underway to develop a qualified target design. This consists of multiple phases that provide an incremental approach intended to reduce the risk of target failure during testing. Additionally, post irradiation examination (PIE) results from each phase will act as a hold point and will guide the course of the subsequent irradiations. The irradiation testing will be used to clarify the following characteristics of $^{238}$Pu production in – pellet swelling; fission gas release; heat generation rates; pellet clad interaction; $^{236}$Pu production; and product yields.

In addition to irradiation tests, chemical process steps will be tested independently using existing materials (i.e., plutonium and neptunium) at ORNL in preparation for an eventual integrated demonstration using irradiated production targets resulting from the technology demonstration effort. As irradiated test targets become available, they will be used in the chemical process testing.

**Summary:** The goal of the $^{238}$Pu Technology Demonstration Project is to establish a qualified target design, irradiate targets, and demonstrate the plutonium chemical processing capability needed to support the program mission. Initial tests will expedite development of the knowledge base necessary for target design. By the end of FY 2013, full-scale production targets will be fabricated and undergoing irradiation. The project will use existing hot cell facilities to process irradiated targets to recover the $^{238}$Pu product and unused neptunium.
This paper reports on those activities to qualify and test production targets as well as activities to validate chemical recovery at the bench scale.

References: