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Isotope Production Target Irradiation Experience at the Annular Core Research Reactor*

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Introduction

As a result of an Environmental Impact Statement (EIS) recently issued by the Department of Energy, Sandia National Laboratories (SNL) has been selected as the "most appropriate facility" for the production of ^{99}Mo. The daughter product of ^{99}Mo is ^{99m}Tc, a radioisotope used in 36,000 medical procedures per day in the U.S.[1] At SNL, the ^{99}Mo would be created by the fission process in UO_2 coated "targets" and chemically separated in the SNL Hot Cell Facility (HCF). SNL has recently completed the irradiation of five production targets at its Annular Core Research Reactor (ACRR). Following irradiation, four of the targets were chemically processed in the HCF using the Cintichem process.

Description Of Work

Five isotope production targets were irradiated in ACRR. Since the targets are similar in outer dimension to an ACRR fuel element, the targets were irradiated in ACRR fuel element locations. In an actual ^{99}Mo production situation, the targets would be located in a flux trap region in the center of a slightly modified ACRR core.[2]

The ACRR is a TRIGA-type research reactor which can be operated in steady-state or pulsed modes. The ACRR is fueled by 236 stainless steel clad UO_2-BeO fuel elements which are 3.75 cm (1.48") in outside diameter and ~52 cm (20.5") in length. Although the nominal steady-state power is 2 MW, the ACRR has been operated at > 4.5 MW. The core resides in a pool ~10 m deep and is cooled by natural convection. For long-term steady-state operation, the pool water is cooled via a shell-and-tube heat exchanger.

The isotope production targets were manufactured by Los Alamos National Laboratory and supplied to SNL. The targets consisted of UO_2 coated stainless steel tubes. The tubes are 45.7 cm (18") in length, 3.18 cm (1.25") in outside diameter, with a nominal wall thickness of 0.0889 cm (0.035"). The inner surfaces of the tubes were prepared using an acid etch, and the UO_2 coating was electrochemically deposited. Coating masses ranged from 18-21 g of fully-enriched UO_2. The ends of the tube were sealed with stainless steel end pieces welded to the tube. The top end piece has a gas fill port with a metal gasket sealed threaded cap.

Prior to its use in the ACRR, each target had to meet strict quality assurance requirements. The coating was visually inspected using a borescope. The target was pressure tested to 2.2 MPa (300 psig). Finally the target was backfilled with 62 kPa (9 psia) of Helium, and leak checked to $<10^{-7}$ std. cm^3/s. In addition to the testing requirements, LANL supplied tube material certifications, welding inspection reports, and coating mass assays.

*This work was performed at Sandia National Laboratories, which is operated for the U. S. Department of Energy under contract DE-AC04-94AL85000.

The Monte Carlo neutron transport code MCNP[3] was used to predict the operating parameters of the targets. One-dimensional heat transfer analysis was used to estimate component temperatures for steady-state target operation.

Results

The predicted energy coupling of the UO_2 coating to the ACRR was ~100 W per g of ^{235}U per MW of ACRR power and varied slightly with the selected core location. Since the ACRR is currently limited to a 2 MW steady-state power level, nominal weight targets would operate at ~5 kW. This constitutes a 1/4-scale test compared to an ~20 kW/target power level for production. Coating temperatures for 5 kW operation were estimated to be ~110°C. Table 1 shows the irradiation parameters for each of the targets.

The separation in the HCF was accomplished with high recovery efficiencies, validating the Cintichem process. This work represented a significant accomplishment in process validation (irradiation as well as chemical separation) and provided valuable experience for progression to full-scale production.

References

1. "Good Golly, Miss Moly: U. S. To Manufacture Life-Saving Radioisotopes," *Nuclear Energy Insight*, 6, October 1996.

2. E. J. PARMA, "Reactor Physics Calculations for ^{99}Mo Production at the Annular Core Research Reactor," *Trans. Am. Nucl. Soc.*, **73**, 401, 1995.

3. J. F. BRIESMEISTER, Ed., "MCNP - A General Monte Carlo N-Particle Transport Code, Version 4A," LA-12625-M, Los Alamos National Laboratory, November 1993.

Table 1. Target Irradiation Parameters.					
Target #	**UO_2 Mass (g)**	**Estimated Power Level[a] (kW)**	**Length of Irradiation (h)**	**Total Activity at Start of Processing (Ci)**	**Estimated ^{99}Mo Inventory[b] (Ci)**
1	25.6	3.8	8	400	15
2	25.2	3.7	10	420	18
3	23.5	3.5	24	550	39
4	25.4	4.1	149	3000	160
5[c]	25.1	4.0	149	3000	160

a. At 2 MW ACRR power.
b. At end of irradiation.
c. Backup target; irradiated but not chemically processed.