Rubidium metal target development for large scale ^{82}Sr production

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Introduction

Strontium-82 ($t_{1/2}$ = 25.5 d) is one of the medical isotopes produced on a large scale at the Isotope Production Facility (IPF) of the Los Alamos National Laboratory (LANL), employing a high intensity 100 MeV proton beam and RbCl targets. A constant increase in the ^{82}Sr demand over the last decade combined with an established thermal limit of molten RbCl salt targets [1,2] has challenged the IPF's world leading production capacity in recent years and necessitated the consideration of low-melting point (39.3 °C) Rb metal targets. Metal targets are used at other facilities [3–5] and offer obvious production rate advantages due to a higher relative density of Rb target atoms and a higher expected thermal performance of molten metal. One major disadvantage is the known violent reaction of molten Rb with cooling water and the potential for facility damage following a catastrophic target failure. This represents a significant risk, given the high beam intensities used routinely at IPF. In order to assess this risk, a target failure experiment was conducted at the LANL firing site using a mockup target station. Subsequent fabrication, irradiation and processing of two prototype targets showed a target thermal performance consistent with thermal modeling predictions and yields in agreement with predictions based on IAEA recommended cross sections [6].

FIGURE 1. Rubidium metal target failure test bed designed to simulate the target environment during failure. The mockup target station is on the right.

Material and Methods

Target failure test: The target failure test bed (FIG. 1) was constructed to represent a near replica of the IPF target station, incorporating its most important features. One of the most vulnerable components in the assembly is the Inconel beam window (FIG. 2) which forms the only barrier between the target cooling water and the beam line vacuum. The test bed also mimicked relevant IPF operational parameters seeking to simulate the target environment during irradiation, such as typical cooling water flow velocities around the target surfaces. While the aggressive thermal effects of the beam heating could not be simulated directly, heated cooling water (45 °C) ensured that the rubidium target material remained molten during the failure test. A worst case catastrophic target failure event was initiated by uncovering an oversized pre-drilled pinhole (1 mm Φ) to abruptly expose the molten target material to fast flowing cooling water (FIG. 2).

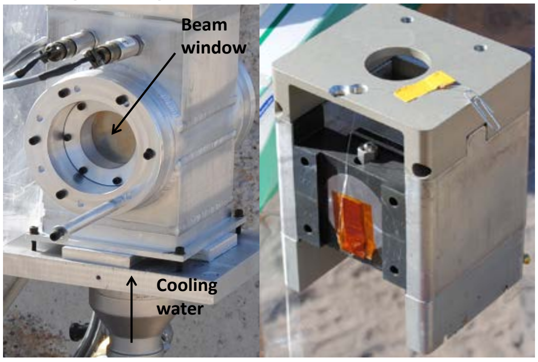

FIGURE 2. Mockup target station (left) and target carrier (right) showing the Rb metal test target with covered, pre-drilled pinhole.

Prototype target irradiations: Two prototype Rb metal target containers were fabricated by machining Inconel 625 parts and by EB welding. The target containers were filled with molten Rb metal under an inert argon atmosphere. Following appropriate QA inspections, the prototype targets were irradiated in the medium energy slot of a standard IPF target stack using beam currents up to 230 µA. After irradiation the targets were transported to the LANL hot cell facility for processing and for ^{82}Sr yield verification.

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Results and Conclusion

During the target failure test, cooling water conductivity and pressure excursions in the target chamber were continuously monitored and recorded at a rate of 1 kHz. Video footage taken of the beam window and the pinhole area combined with the recorded data indicated an aggressive reaction between the Rb metal and the cooling water, but did not reveal a violent explosion that could seriously damage the beam window. These observations, together with thermal model predictions, provided the necessary confidence to fabricate and fill prototype targets for irradiation at production-scale beam currents. X-ray imaging of filled targets (FIG. 3) shows a need for tighter control over the target fill level. One prototype target was first subjected to lower intensity (< 150 µA) beams before the second was irradiated at production level (230 µA) beams. During irradiation, monitoring of cooling water conductivity indicated no container breach or leak and, as anticipated given the model predictions, the post irradiation target inspection showed no sign of imminent thermal failure (see FIG. 4). Subsequent chemical processing of the targets followed an established procedure that was slightly modified to accommodate the larger target mass. TABLE 1 shows that post chemistry ^{82}Sr yields agree to within 2 % of the in-target production rates expected on the basis of IAEA recommended cross sections. The table also compares ^{82}Sr yields from the Rb metal targets against yields routinely obtained from RbCl targets, showing an increase in yield of almost 50 %.

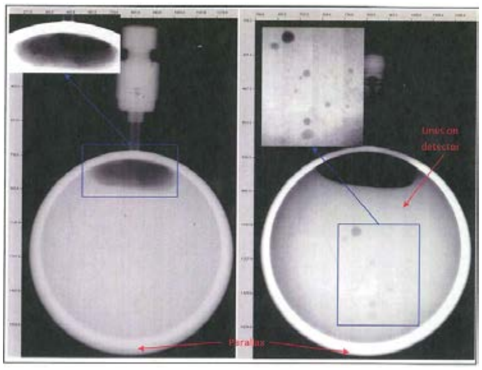

FIGURE 3. X-ray images of a filled target, showing an under-fill.

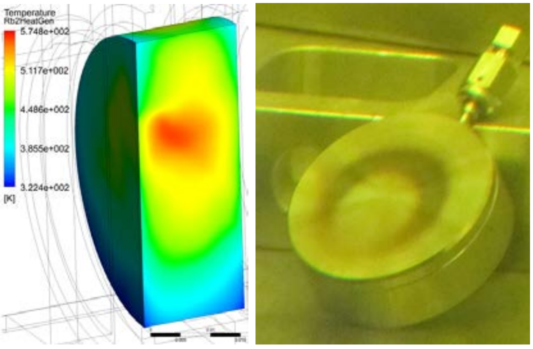

FIGURE 4. Predicted target temperature distribution at full beam current (left) and post irradiation inspection of a Rb metal prototype target in the hot cell (right).

target (energy window)	instantaneous production rate (µCi/µAh)	
	Predicted	Measured
RbCl (63.1-42.2 MeV)	206.9	203.1
Rb metal (62.0-42.1 MeV)	300.6	296.8

TABLE 1. Predicted and measured production rates for practical RbCl and Rb-metal targets.

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